SCIENCE TEACHER'S WORLD

Teacher's edition of SCIENCE WORLD November 18, 1959

Using *Science World* in Your Teaching

Atomic Artillery (pp. 11-14)

General Science and Physics Topic: Particle accelerators

About This Article

By now, the terms cyclotron and synchrotron have become household words. But very few young people have much of a notion as to what the differences are between the two. Nor can they say how these two differ from the *linear accelerator*. Even the initiated may not have heard of the "synchroclash"—an atom smasher of the future. This article undertakes to explain the principle on which all atom smashers operate, and to clarify some of the differences among the variety of atom smashers now in use or soon to be built.

Topics for Class Discussion

1. How is a TV set like a linear accelerator?
2. Describe the linear accelerator being built at Stanford University in California.
3. What is the advantage of the cyclotron over a linear accelerator?
4. Describe the basic structure of a cyclotron.
5. What is the advantage of a synchrotron over a cyclotron?
6. Describe the synchrotron at the Brookhaven National Laboratory.
7. Explain why it becomes more and more difficult to increase the speed of acceleration while particles are being accelerated.
8. What kind of information about the atom is being discovered through the use of atom smashers?

Ions in the Sky (pp. 8-10)

General Science Topic: Exploring space
Earth Science Topic: The "structure" of the atmosphere
Physics Topics: Ionization (of gases), electromagnetic induction
Chemistry Topic: Atmospheric gases

About This Article

The recent international geophysical year—a year of cooperation on a worldwide scale to obtain a synoptic view of what is going on in the atmosphere, in the oceans, and in the interior of the Earth itself, has yielded some outstanding discoveries. More significantly, it has opened up "unknowns" that are calculated to motivate continuous research for many years to come—research that involves exploration of areas of the upper atmosphere not yet accessible to man himself, but accessible to rockets equipped with instruments that transmit or bring back information.

The article describes the structure of the six layers of the Earth's atmosphere and the dynamics of the upper layers under the influence of the Earth's magnetic field and of the sun's shower of radiation. But the description is in terms of continuing exploration of these upper regions by way of rocketry.

Teaching Suggestions

Students might be assigned to make a scale diagram of the six layers of the Earth's atmosphere—using information obtained from this article. Additional data may be extracted from the cover.

Individual students might report to the class (or club) on (1) the troposphere, (2) the stratosphere, (3) the chemosphere, (4) the ionosphere, (5) the mesosphere, (6) the exosphere.

Nerves—The Links of Learning (pp. 16-19)

Biology Topics: Reflex acts, reflex arc, conditioned reflexes, instincts, learning behavior

About This Article

This is a straightforward description of behavior in terms of nerves, neurons, and their connections. Some experiments with tadpoles are described. For its style and interest, the article is recommended as supplementary reading by students in biology classes studying a unit on the nervous system.

Tomorrow's Scientists (pp. 25-28)

Isolation of Enzyme Sucrase

From a teacher's point of view, David Lloyd's report features a continuous and expanding interest that began in a 7th grade class and continued for more than three years afterward. During these years, David was led on from problem to experiment and back to problem. He uncovered new techniques and learned how to apply them. Even as he makes his "final" report, he has ". . . a great many different experiments planned." Who knows, he may well be ticketed to a *lifetime* of research.

While most students will lack the experience and knowledge-background to understand David's report in all its technical details, there are, nevertheless, a number of points—"lessons"—that make the article recommended reading for all aspiring young scientists.

The teacher might well call attention to these points:

1. "Before I began my research, I did some armchair research." By "armchair research" David obviously means learning as much as possible from reading.

2. "Both the centrifuge and the incubator were homemade equipment." The imagination and manipulative ability to devise ways of obtaining information from Nature are often the keys that are needed to unlock new explanations of natural phenomena.

3. "I was curious as to why I should get *two* active precipitates. I found my answer to this question in a book entitled . . ." Curiosity is the hallmark of a scientist. And this curiosity leads him not only to the laboratory, but also to the library, where he can communicate with other investigators by way of books and journals.

4. "I have a great many different experiments planned." Research is never "finished." As one question is answered, new questions arise. This is what makes research so endlessly exciting.

Here's How and Why (p. 15)

Teaching Suggestions

The list of things to do and see under "What Happens and Why" may serve as very attractive "openers" by teachers of physics or general science for lessons on surface tension, center of gravity, Newton's laws of motion, and others.

You may assign one of these as a homework activity, coupled with the requirement that each student bring in a written report on his observation and several hypotheses to explain what he observed. Hypotheses might then be tested in class the next day.

Finally, reading assignments might be made that would extend the observations to the level of stating a scientific principle.

Project and Club News (p. 28)

Suggestions made in this article offer opportunities for reviewing the optimum use of various reference resources —for projects and class assignments.

Your Sponsor Handbook and the Science Talent Search leaflet on *How You Can Search for Science Talent* include material that may be particularly helpful to projecteers.

The Development of Scientific Ideas

Science education and its improvement in the United States was the theme of the Tenth Thomas Alva Edison Foundation Institute, held November 19-20 at New York University.

Among featured speakers was Dr. Stephen Toulmin of the Nuffield Foundation of London, who is now John Dewey Visiting Professor of Philosophy at Columbia University. Dr. Toulmin graduated in mathematics and physics at Cambridge University. He is now at work on a comprehensive program of books and films dealing with the history and philosophy of science for high school and college students. Some of his remarks follow:

"Many working scientists consider that the history of science is educationally a useless subject. Why, they ask, study discredited solutions of dead problems, when living science is so full of urgent and active ones? If the history of science is going to consist of anecdotes about great scientists, or exhaustive lists of their names, dates, and works, this attitude is understandable. Yet I shall argue that, intelligently digested and presented, the development and evolution of scientific thought and ideas should be an indispensable element in general education.

"The value of the subject lies not in its power to turn everyone into scientists—the only way of doing that is the full professional apprenticeship in a science. Rather it gives us the sort of understanding of science we need to have as men of balanced education, and also as citizens.

"Only a study of the growth of scientific method and ideas can teach one what science has been, is, and can become, how it has influenced the whole of our thought, our literature and even our religion—and how easy it would be (in this respect) to kill the goose that laid the golden egg by diverting all competent scientists onto (for instance) military technology.

"General education is not helped by teaching first steps in physics or zoology. Rather, it requires intelligent study of the development of, say, cosmological ideas down the ages, or ideas about the constitution of matter, or ideas about the history of the earth and of life.

"These can, in my experience, be taught effectively to students of all kinds, and the subject is particularly welcomed by those who are not going to become professional scientists—for the insight it gives into the nature of science.

"At present, the means of teaching the subject universally are not available, and the whole question of a suitable syllabus has to be thrashed out. But these are things easily done, if the fundamental decisions are made.

"I look forward to the day when it will be a public mark of ill education *either* to think of science as the same as technology (so confusing the fruit of the tree with its sap, which are ideas worked out by men from motives of critical curiosity alone, without an eye to practical results) *or* to suppose that science is intellectually all-powerful, and can answer for us ethical and political questions as well as theoretical and practical ones.

"The time is ripe for a wholehearted effort to get an understanding of science in its broadest cultural connections accepted as a mandatory element in the syllabus for the last years of high school and in junior colleges."

NSTA—AAAS Meets

The annual joint meeting of the National Science Teachers Association with other science teaching societies affiliated with the American Association for the Advancement of Science will be held this year at the Hotel Sherman in Chicago, Illinois, December 27-30. All who plan to attend should make hotel reservations by writing to the AAAS Housing Bureau, Suite 900, 134 North La Salle Street, Chicago, Illinois.

Joint sessions involving NSTA and one or more of the other societies will include a general session on Sunday morning, December 27, and an elementary science session on Tuesday afternoon, December 29. An abbreviated program of NSTA sessions follows:

Sunday, December 27

General Session—"Man and Space Travel," George Bernard Shaw Room, 10 a.m.

Speaker: John A. O'Keefe, Associate Chief, Theoretical Division, Goddard Space Flight Center, National Aeronautical and Space Administration, Washington, D. C. "Surface of the Moon."

Speaker: James C. Fowler, Curator of Education, Cranbrook Institute of Science, Bloomfield Hills, Michigan. "The Place of Planetaria in Teaching Space Science."

Concurrent Sessions—"Here's How I Teach Space Science," 2 p.m.

Monday, December 28

Symposium on K-12 Planning—Presentations; Bal Tabarin Room, 9 a.m.

Symposium on K-12 Planning—Round Table Discussions; Bal Tabarin Room, 2 p.m.

Tuesday, December 29

Symposium on K-12 Planning—Summary of Round Table Discussions; Bal Tabarin Room, 10 a.m.

Staff and Committee Reports—"This Is Your NSTA"; Bal Tabarin Room, 11 a.m.

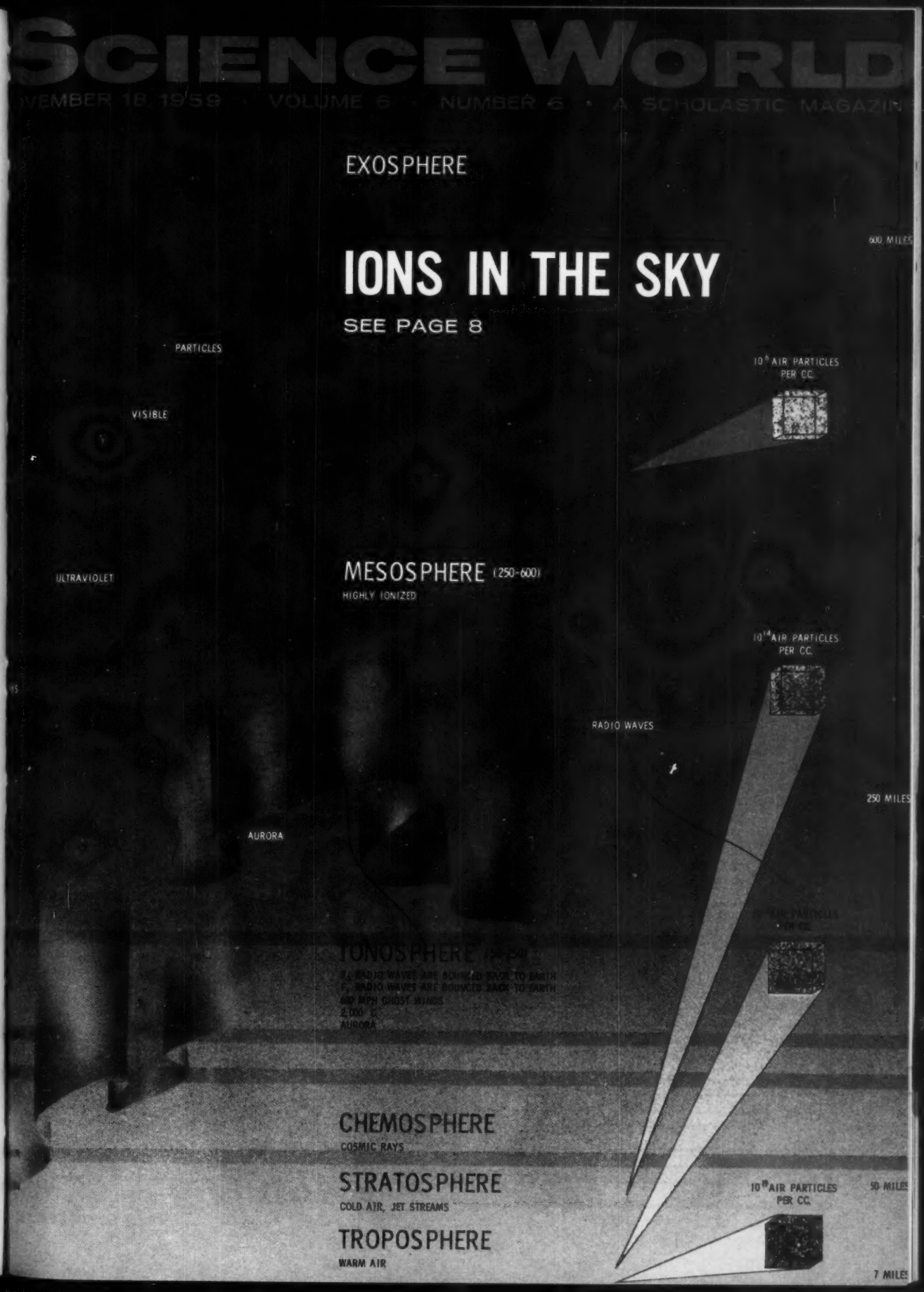
Joint Elementary Science Session; Assembly Room, 2 p.m.

Wednesday, December 30

Conference on Future Scientists of America Program, Jade Room, 9:30 a.m.

An invitational conference will be held to provide opportunities for scientists to hear about, to discuss, and to counsel on the program of services and activities of the Future Scientists of America Foundation of the National Science Teachers Association. Special attention will be given to proposals for a Future Scientists of America Youth Activities Program.

SCIENCE WORLD
VEMBER 18, 1959 · VOLUME 6 · NUMBER 6 · A SCHOLASTIC MAGAZIN



IONS IN THE SKY

SEE PAGE 8

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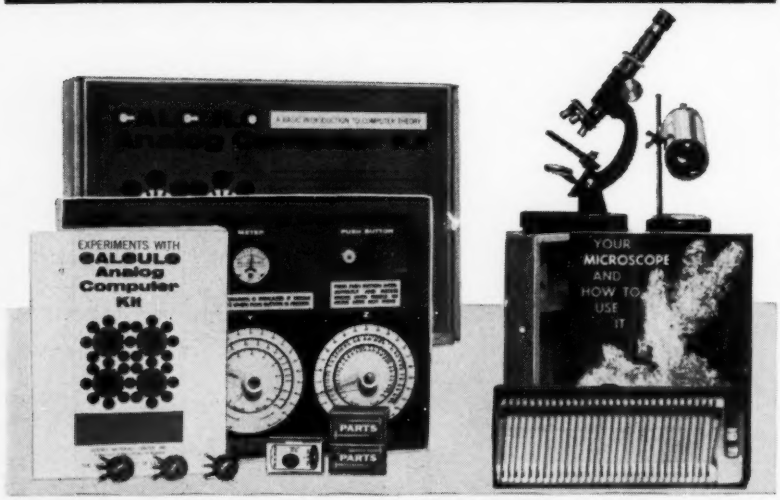

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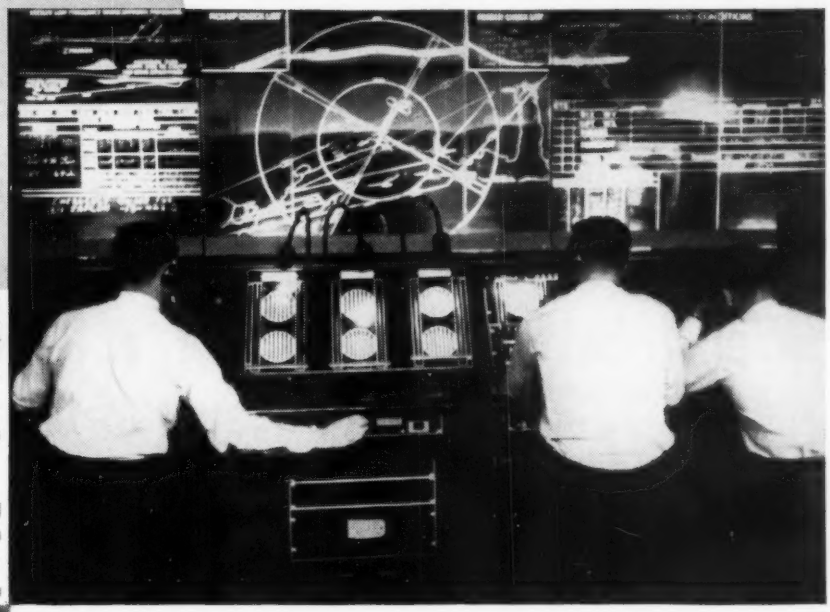

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Naturally, this is just one example of how designers are taking advantage of the unique properties of Nickel-containing metals. In the future, however, you may be designing a machine—not a spectacular all-weather push-button roof. You might need a metal that resists corrosion, or wear, or high temperatures. Or one that meets some destructive combination of conditions. Here, too, a Nickel-containing metal could be the answer.

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SCIENCE WORLD

SCIENCE WORLD, published fortnightly, 16 times during the school year September through May. Second-class mail privileges authorized at Dayton, Ohio. Contents copyright, 1960, by Scholastic Magazines, Inc. SUBSCRIPTION PRICES: $1.50 a school year each, or $1.00 a semester each. Single subscription, Teacher's Edition, $2.00 a school year. Single copy, 10 cents. Office of Publication, McCall

SCIENCE WORLD

NOVEMBER 18, 1959 • VOLUME 6 • NUMBER 6 • A SCHOLASTIC MAGAZINE

Published with the official cooperation of the National Science Teachers Association

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Science in Quotes

In science, the methods are supremely important. A history of science is to a large extent a history of the instruments, material or immaterial, created by a succession of men to solve their several problems. Each instrument or each method is, as it were, a crystallization of human genius. Look at the cockpit of an airplane, and ask yourself what was the origin and development of each one of its tools; it is an endless story of patient accumulation and adjustment. In art, on the contrary, the results matter more than the methods. . . .

We cannot penetrate the thought of Faraday or Poincaré without a sustained effort, but a Greek statue reveals to us immediately the best of Greece. . . . —GEORGE SARTON

...AND OVER 5000 CAN BE HELD IN THE PALM OF YOUR HAND

Aeronutronic, Ford Motor Company's newest division, has developed a minute electronic computer device called the BIAX computer element. In combination with other components, BIAX elements can perform a million operations, memorize a dictionary or solve a thousand algebraic equations in the blink of an eye.

Just a few years ago tiny transistors replaced bulky vacuum tubes—cut down the size of computers. Now this amazing Ford-developed BIAX element is expected to reduce greatly the number of transistors and other components in computers. This will make it possible to build better, more compact computers at a lower cost.

This is just one of the recent contributions of Aeronutronic engineers and scientists. They are preparing many diverse products for the space age by investigating nuclear physics, rocket engines, space ship design, computer development, air cushion vehicles—employing nearly every field of advanced scientific knowledge in doing the job.

Aeronutronic's discoveries and developments will pay off for future space travel just as Ford Motor Company's Engineering and Research Center pays off for today's highway travelers in the Ford Family of Fine Cars.

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Letters

Temperature of Stars

Dear Editor:

How do astronomers determine the temperature of distant stars?

Chand Bhasker
712 Fillmore
Topeka, Kansas

Answer: One way of determining the temperature of a star is to measure the amount of heat it radiates. A star's heat is measured by placing a thermocouple at the focus of a telescope. The thermocouple is a device no larger than the head of a pin, which generates electric current when heated. The amount of current indicates the heat at the thermocouple. If a star's size and distance are known, its temperature can then be determined by a simple formula.

A star's temperature can also be determined from its color spectrum. Most stars will generate more light in one section of the spectrum than in another. In general, the shorter the wave length of the light emitted by the star, the hotter it is. For example, a "blue" star has a much higher temperature than a "red" star.

Why Water Doesn't Burn

Dear Editor:

Why doesn't water burn, since it is composed of hydrogen and oxygen, which burn easily when mixed together?

George Trotter
Ainsworth, Iowa

Answer: The actual burning of a mixture of hydrogen and oxygen gas is the way in which water is formed. Normally gas molecules of hydrogen and gas molecules of oxygen can be mixed together without burning. However, a spark can set off a violent explosion, or "burning." The actual heat of the burning is caused by the molecules of hydrogen and oxygen coming more closely together in a new combination, or compound, called water.

As long as the hydrogen and oxygen molecules are tied together as a water molecule, they cannot react with each other and burn. If an electric current is passed through water, however, it breaks up the water molecules into oxygen gas molecules and hydrogen gas molecules. These molecules can then burn again, once more forming water.

Man-Made Elements

Dear Editor:

In the article "Glenn T. Seaborg, Man Who Made Elements" (*Science World*, Oct. 21, 1959), you mention 14 man-made elements. I know only neptunium, plutonium, americium, curium, berkelium, californium, mendelevium, einsteinium, fermium, and nobelium. What are the other four?

Karen Mahaffey
Whitehall Yearling High School
Columbus, Ohio

Answer: The other four elements are technetium, discovered in 1937 by bombarding molybdenum with deuterons, promethium, discovered in 1945 as a fission product of uranium, astatine, found in 1940 through bombardment of bismuth with helium ions, and francium, found as a natural radioactive product of actinium. (See the October 7, 1959, issue.)

Electric Eels, Again

Dear Editor:

You mentioned in your letters column (*Science World*, Sept. 9, 1959) that the current in an electric eel flows from the head, which is positive, to the tail, which is negative. I thought that electric current was the flow of electrons, which move from negative to positive. Which is right?

George Hoeg
114 Robert Place
Hawthorne, New York

Answer: Both are right. The flow of electrons and electric current are two different things. The electric current we usually talk about flows in a wire at the speed of light. Although no one is sure what this current is, it is believed to be some kind of wave motion, which travels along electrical conductors.

When electricity was first discovered, this current was believed to flow from positive to negative. This convention has been kept to this day for making calculations or designing electrical circuits. However, if current was thought of as flowing from negative to positive, it would not change the design of electrical circuits.

Electron flow, on the other hand, is the flow of negative particles called electrons. The electrons move along a wire from negative to positive because of their charge. The electrons move much more slowly than the electric current. The speed of electrons depends on the voltage along the conductor. In general, the term "electric current" does *not* mean electron flow.

Electron Shell

Dear Editor:

Why are the electron shells of an atom classified as the K-shell, L-shell, M-shell, N-shell, etc.?

Dennis Oeth
715 Ramona St.
Dubuque, Iowa

Answer: The capital letters K, L, M, etc., which describe the energy levels of electrons around an atom, are derived from complicated mathematical equations developed by nuclear physicists. They have no special meaning except that they conveniently fit in well with previous mathematical descriptions of the atom.

Detailed understanding of the electronic structure of the atom began with the work of Niels Bohr in 1913. The concept of electron shells surrounding the atom, which is the basis of our periodic system, is largely due to the "exclusion principle" developed by the physicist W. Pauli, Jr., in 1925. Many other physicists have contributed over the years to the development of the electron shell picture of the atom.

Largest Explosion

Dear Editor:

What was the largest explosion that ever took place on the earth?

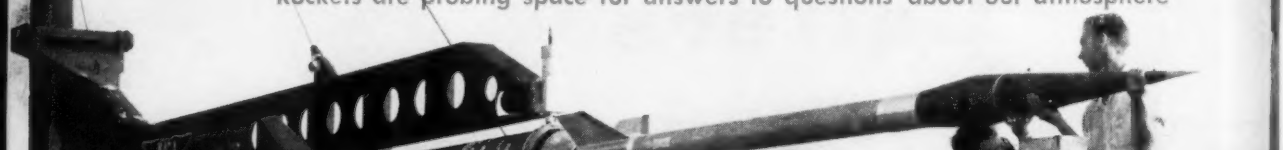
Richard Pikula
Amsterdam
Saskatchewan, Canada

Answer: The largest known explosion on earth occurred in 1883, when the volcanic island of Krakatoa, in the Dutch East Indies, erupted and blew up. The explosion was probably caused by water seeping into the molten lava in the core of the volcano and being turned into steam. The steam pressure built up to the point where the whole island, really the top of a volcano above sea level, just blew off like the lid of a pressure cooker.

A vast cloud of dust and ashes darkened the sky for a hundred miles around. The sound of the explosion was heard as far as 3,000 miles away.

IONS IN THE SKY

Rockets are probing space for answers to questions about our atmosphere



By ELIOT TOZER

U.S. Army photo

Nike-Cajun rocket, shown on launcher, can carry instrument payload of about 50 pounds to heights of more than 100 miles.

RIGHT now, as you read this, scientists are working round the clock in the bitter cold of Manitoba to fire a Nike-Cajun rocket straight up into the Earth's upper atmosphere. Researchers at the launch pad on Wallops Island, Va., are shooting two Nike Asps to a height of 150 miles. An Aerobee is being fired from White Sands, N. M. A total of 10 specially-instrumented rockets will be launched by United States scientists and engineers between November 16 and 22. Many interesting hypotheses are behind these shots.

One of the shots will measure atmospheric winds up to 150 miles. Another will investigate X rays and ultraviolet light radiations from the sun. The Canadian shots will measure water vapor at altitudes of 18 to 60 miles and scout the Earth's magnetic field. Other shots are being made to count micrometeorites or to make a detailed study of solar radiations.

International Rocket Week

For this is International Rocket Week. During the next few days, scientists all over the world will probe nearby space to speed up the collection of data about the Earth's atmosphere, radiations from the sun, and the tiny meteors that enter the Earth's blanket of air. They will also try to chart the dangerous seas of charged particles that ebb and flow above the Earth.

The effort is part of the program for International Geophysical Cooperation-1959, known as IGC-59. This is a world research program which took up where the International Geophysical Year (IGY) left off in December 1958.

Many phenomena in our atmosphere remain unexplained. All during the IGY, scientists sent fewer than 200 rockets into Earth's upper air. Yet a careful study of the ionized oxygen and nitrogen in these distant reaches may help us solve the mystery of the Earth's magnetic field. More important, it might tell us much about our nearest star, the sun. For, just as the sun heats the Earth, warming the air near the Earth and causing the winds to blow and the rains to fall, it heats the upper air over the poles—but in a most unusual way. It causes ghostly winds to whistle through the far emptiness at 600 mph, and it convulses the dark and hostile sky with great electrical storms.

As you know, light and infrared rays stream outward in vast quantities from the sun's photosphere. X rays beam out from its corona. The gigantic storms on the sun's surface spew out charged particles, ultraviolet rays, and radio waves.

Little of this radiation reaches the Earth. As the rays speed toward us, they run into more and more molecules of oxygen and nitrogen. Or they plow into particles that have a peculiar attraction for them and are absorbed by them. Thus, infrared rays are stopped at an altitude of 25 miles. Ultraviolet rays get only as far as 70 miles from Earth.

The atmosphere's temperature, pressure, and composition change with altitude, and the sun's rays react differently with the molecules at each altitude. Therefore, scientists have classified the atmosphere as having six layers—like a six-layer cake—each with a character of its own.

Seven Layers of Air

Let's take a trip up through each of the "layers" that separate our Earth from outer space. Let's stop off at each layer to "see" the phenomena that puzzle scientists.

One criterion of classification is the density of the molecules in our atmosphere. In the lower layer, the warm, dense *troposphere* (0-7 miles), there are about 400 quintillion molecules in each cubic inch of air. Their mean free path—that is, the mean distance that a molecule can travel before it bumps into its neighbor—is about 1/1,000,000th of an inch. Only sunlight penetrates this dense layer in significant amounts. The sunlight, reflected by the Earth as heat (infrared radiation), warms the air from beneath so that it rises, causing wind and weather.

Little radiation but light comes through the second layer, the *stratosphere* (7-20 miles). Though cold (—40 degrees C), thin, and dry, it is similar to the troposphere. It is often laced with cirrus clouds (ice crystals) and frequently torn by the 200-mph jet streams that whip along the high shear line between subtropical air and the cold air flowing

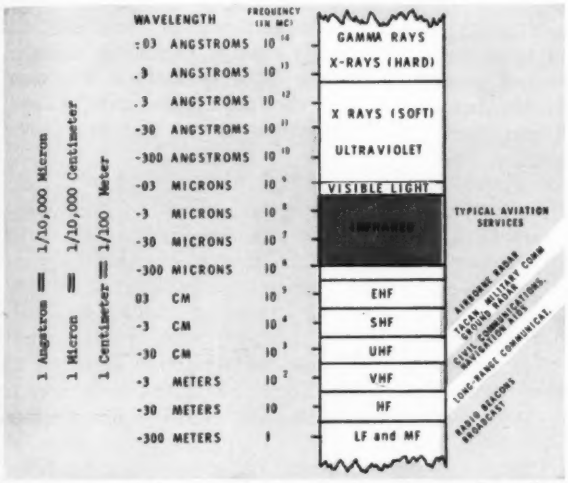
down over the Earth from the poles.

But the top of the stratosphere marks a boundary. Below an altitude of about 20 miles, Earth's atmosphere is generally friendly. Above 20 miles lies the hostile "radiation atmosphere" that will make manned space flight so perilous. It is thin, cold, and seething with high-energy atoms and electrons. (Man always seems to fear phenomena he knows little or nothing about.)

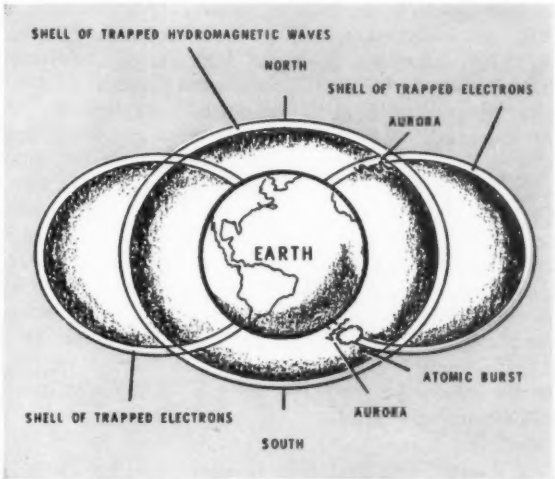
The first of the layers in the radiation atmosphere is the *chemosphere* (20-50 miles). It is a huge photochemical laboratory. Here, at an altitude of about 40 miles, radiations emitted by atomic hydrogen in the sun's corona ionize nitric oxide, releasing great quantities of electrons. Thanks to this electron layer, called the D region, you can pick up the big beat of your favorite band by radio. For the electrons act as a mirror. They bounce radio waves back to Earth, increasing the distance over which radio stations can transmit.

But the D region is ever restless. Pulled and hauled by the sun's rays, it rises and settles. And sometimes it betrays the broadcasters who hope to use it as a relay station. When radiations from the sun's corona beam through the upper atmosphere and ionize the particles in the D region, radios throughout much of the world may black out. For electrically charged particles may also divert radio waves. During such black-outs, radio experts scramble to find new frequencies that will break through the ionized layer to other "mirror" layers above, so they can go back on the air.

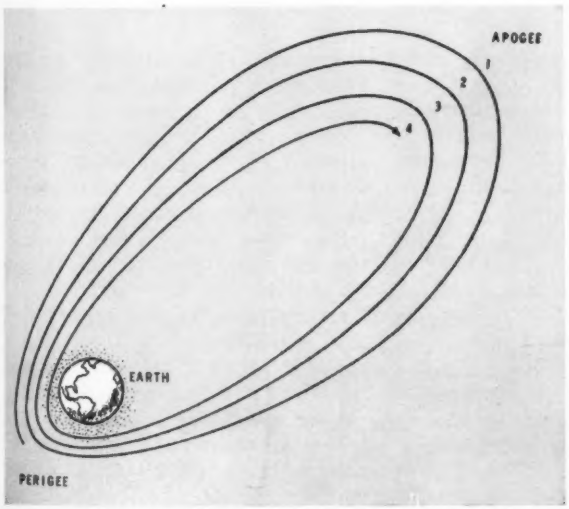
In the chemosphere, molecular oxygen breaks down and recombines to form ozone (O_3). Cosmic rays—streams of hydrogen protons from the sun—crash into molecules of air and shatter into secondary particles.



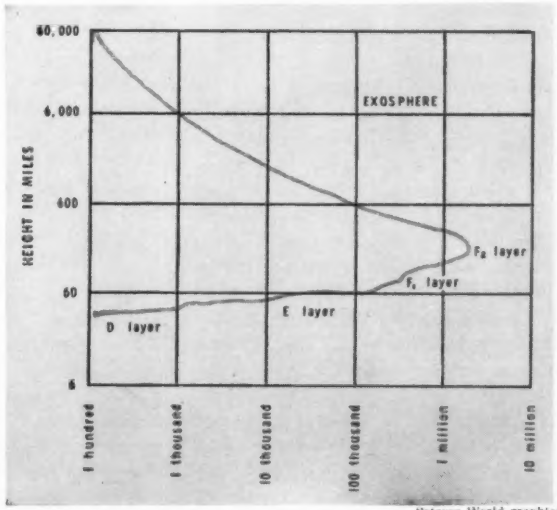
The spectrum of electromagnetic radiation in space, from the long wavelengths of broadcast radio to short wave rays.



Atomic explosions create two energy shells around the Earth. The shell of electrons follows the Earth's magnetic field.



Each time an orbiting satellite passes near the Earth, the drag of the atmosphere slows it down and narrows its orbit.



Science World graphics

Number of ions in the atmosphere increases with altitude. Peak, at about 150 miles, is the center of the ionosphere.

In July 1956 a group of Navy scientists set sail on the USS *Colonial* from San Diego with a hold full of special rockets called rockoons. Because the giant Aerobees and Nike-Cajuns take three or four minutes to reach their peak altitude (too long after the urgent message from an IGY warning center that a storm has just erupted on the face of the sun), the scientists hoped to float their rockets beneath balloons at 80,000 feet and launch them from there to get a head start.

For 11 days the scientists waited for the sun to cooperate. Then the observatory at Climax, Colorado, flashed the word that a flare had erupted. The rockets sped upward—too late to catch the earliest radiations, but early enough to make a surprising discovery. The sun had emitted a strong burst of X rays, not ultraviolet radiation, as the scientists had expected.

Ionosphere—Mystery Area

Within the past few months, scientists have theorized that these X rays produce the so-called E region in the *ionosphere* (50-250 miles) by ionizing molecular oxygen. Usually the electrons in the E region are plentiful enough to bounce back the shorter wave length rays of the police broadcast band.

And just above the E region are the F_1 and F_2 regions that bounce back short wave broadcasts. Television waves, shortest of all, slip through all three regions.

The ionosphere is a layer of many paradoxes. The temperature is high—the National Aeronautics and Space Administration estimates it may be above 2,000 degrees C—but the air is bitterly cold. The temperature over the poles is higher than it is over the temperate zone. Ghost winds of 600 mph stream silently through the ionosphere, but they would barely slow down a space vehicle. The air density is very low.

The high-temperature cold is easy to explain. Although the kinetic energy of molecules makes them hot, there are so few (mean free path at the top of the ionosphere is 43 miles) that they have little effect on anything they touch. If, as a passenger in some space ship of the future, you stuck your hand out the window (quite unlikely!), you would probably not suffer frostbite—at least on the side toward the sun. Your hand would be warmed in the same way the Earth is warmed.

The high polar temperatures are also easy to explain. They are caused by the sun—but in a most indirect and unusual way.

As you know, the recently discovered Van Allen belts of intense radiation are made up of charged particles. These are trapped by the lines of force of the Earth's magnetic field and forced to spiral along them toward the poles. There, says Dr. Robert Jastrow, chief of NASA's Theoretical Division, "the interaction between the trapped particles and the atmosphere has two major consequences. First, we are rather certain that the aurora borealis and aurora australis result from the excitation of the arctic and antarctic atmospheres by collisions between the air atoms and the particles trapped in the outer zone. Second, the temperature of the auroral zone will be raised by the energy transferred in collisions between the trapped particles in the outer belt and the atoms and molecules of the upper atmosphere."

But the ghost winds are not so easy to explain. Do the hot molecules rise for the same reason that warm air molecules rise at the surface of the Earth, or are they whipped into their frenzied flow by electrical energy? We do not know the answer.

But scientists plan to test several hypotheses. They are able to study the drift of man-made sodium flares and of rocket-launched grenade bursts. From these they have learned that these nightmarish winds blow from the west and are strong in the winter, and blow from the east and are less strong in the summer.

Highway for Whistlers

These winds make their own contribution to the electrical turbulence that rages just a few miles above our heads. As they blow charged particles across the lines of magnetic force, they seem to have a dynamo effect, generating great sheets of electricity. The action of the particles and the sheets of electricity causes wild fluctuations in the Earth's magnetic field.

Although the air is far less dense than a good laboratory vacuum (5,000,000,000 particles per cubic inch is about as good a vacuum as we can produce), the upper atmosphere is not completely silent. Arcing through it and, indeed, pinging outward 7,000 miles into space are strange "whistlers."

When a long electromagnetic wave from a flash of lightning rises through the ionosphere, it sometimes follows the lines of force of the Earth's magnetic field—as though it were a highway—and curves down into the opposite hemisphere, only to bounce back again. Whistlers are, then, echoes of lightning bounced from the opposite hemisphere.

In 1955 a scientist in the Aleutian Islands and one in New Zealand actually caught the same whistler zinging back and forth between them, each echo growing deeper and longer than its predecessor.

The Quest Goes On

Above the ionosphere is the *mesosphere* (250-600 miles). We know little about it except that its temperature is high and that it is highly ionized (mainly atomic oxygen). Since it is so thin, however, it probably has a low electron density.

Finally, beyond the mesophere is the *exosphere*, the ill-defined fringe of the Earth's atmosphere. Here, at an altitude of about 625 miles, is the critical level, the level at which the mean free path is so great that some molecules do not experience a collision at all and speed upward into space.

Although International Rocket Week ends on November 22, scientists will by no means stop their curious probing of the upper atmosphere. There is still much to learn about its daily and seasonal changes, about its composition above 65 miles, about other sources of heat than the Van Allen belt, and about the relationship between this violently churning sea of electricity and Earth's weather.

We also hope to learn more about the "windows" in the atmosphere, the non-absorbing channels along which we will be able to communicate with tomorrow's space ships. And we must probe the upper atmosphere to learn more about our great solar engine, the sun.

ATOM SMASHERS

the Heavy Artillery of Science

By SIMON DRESNER

THE atom carries an expensive price tag. Nuclear physicists are finding that as they get deeper and deeper into the structure of the atom they need larger and larger machines to explore the forces in the nucleus.

The impressive achievement of Marie Curie, who discovered radium in a laboratory that was a shed, seems remote from the activities of modern physicists. Today's nuclear scientist needs a million-dollar atom smasher, a half-dozen buildings to house the equipment, and hundreds of scientists, engineers, and technicians to run it. The nucleus of the atom is charging a high price for every secret it gives up.

Typical of the huge atom smashers is one recently authorized by Congress, at a cost of $29,000,000, for the Argonne National Laboratory near Chicago. It is a machine that will whirl atomic particles around a ring-shaped magnet and speed them to nearly the velocity of light. These high speed particles will be fired at nuclear targets, penetrating the nucleus of the atom, to

130,000 miles in only one second—that's how fast atomic particles will race around circular tunnel of synchrotron, between poles of magnets (*left*). Surveyors are lining up magnets of huge atom smasher at Brookhaven National Lab, N. Y.

Brookhaven National Laboratory

Brookhaven National Laboratory

This knobby machine gives particles their first high-voltage kick before they are whirled around the synchrotron. The brass spheres hold 750,000 volts—500 times the voltage on TV picture tube.

reveal the fundamental structure of nuclear matter and the nature of nuclear energy.

It is the size of such machines that is responsible for their million-dollar cost. The Argonne atom smasher, for instance, has a ring magnet 200 feet in diameter, weighing 4,000 tons.

Cannon to Shoot Particles

Other machines are even larger and more costly, such as one planned for the Brookhaven National Laboratory in New York. This will cost $30,000,000, and have a ring magnet 1,000 feet in diameter. Largest magnet of all is part of a Russian atom smasher, a 200-foot steel ring weighing 36,000 tons.

Why should the Argonne atom smasher require 4,000 tons of steel and 7,000,000 watts of electrical power to smash such a tiny bit of matter as an atomic nucleus?

Half of the reason is that the fundamental particles of matter in the nucleus are held together by enormously strong forces.

The other half of the reason is that the nucleus is so tiny that it can be penetrated and broken apart only by equally small particles, such as protons or electrons. An accelerator is actually an atomic cannon which shoots such particles at the nucleus of an atom in an effort to break it apart.

Whether the particle shot at the nucleus will have sufficient force to smash it depends on its speed. From Newton's second law of motion, we know that the force on a body is proportional to its mass multiplied by its acceleration. When an atomic particle strikes its target, both mass and velocity determine the force of the impact.

Since protons and electrons have such small mass—millions of times smaller than a rifle bullet—they must be accelerated to speeds many millions of times faster than that of a bullet. Only then do they develop sufficient force to smash the nucleus.

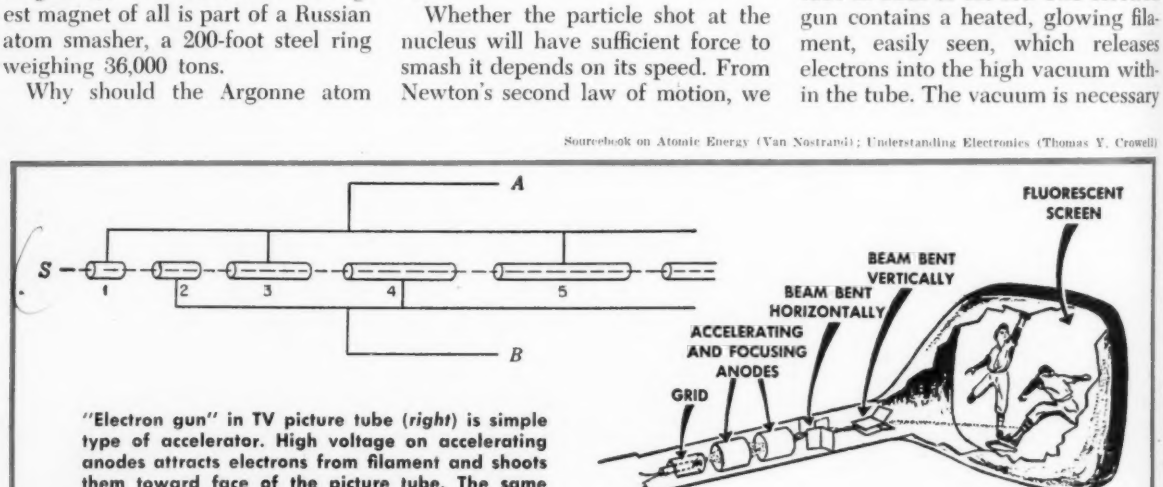
For example, a new accelerator at Stanford University will speed up electrons to the point where their velocity will be only one hundred millionth of one per cent away from the speed of light (the speed of light is about 186,000 miles per second).

Basically, an accelerator is simply a device which speeds up streams of electrically charged particles—such as electrons or protons, or ionized molecules—to the high velocities needed to penetrate the nucleus of an atom.

Atom Smasher in Your TV

Practically every home in the United States contains a simple particle accelerator. It is none other than the picture tube of your TV set. The TV picture is actually created by a narrow beam of speeding electrons striking a fluorescent coating on the face of the picture tube. This electron beam is shot out from an "electron gun" in the neck of the tube in back of the set. The electron gun contains a heated, glowing filament, easily seen, which releases electrons into the high vacuum within the tube. The vacuum is necessary

Sourcebook on Atomic Energy (Van Nostrand); Understanding Electronics (Thomas Y. Crowell)



"Electron gun" in TV picture tube (*right*) is simple type of accelerator. High voltage on accelerating anodes attracts electrons from filament and shoots them toward face of the picture tube. The same principle is used in linear atom smasher (*above*), but with many more anodes and higher voltages.

to keep the electrons from colliding with air molecules and giving up their energy to them. Even very thin air will stop electrons as effectively as a brick wall.

Since the electrons have a negative charge, they will be attracted by any positively charged metal electrode within the tube. And they will gather speed as they travel toward it. In the TV tube "electron gun," the positive electrodes are in the shape of hollow cylinders or rings. The electrons speed right through the center of the rings and onto the face of the picture tube.

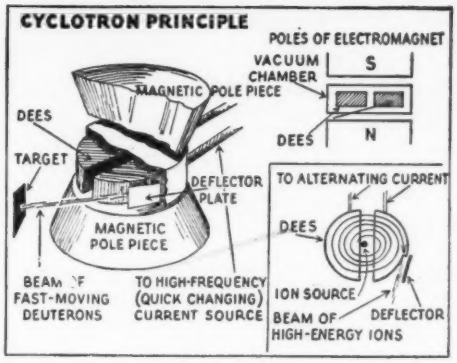
The positive electrodes have a very high voltage on them—usually between one thousand and three thousand volts. This voltage accelerates the electrons to high velocities. Thus they transfer enough energy to the atoms in the fluorescent coating so that they glow. Occasionally an unusually fast electron in the beam will disturb an atom to the point where it emits an X ray. The X rays, however, are not strong enough to harm even the closest viewer.

Pushed and Pulled

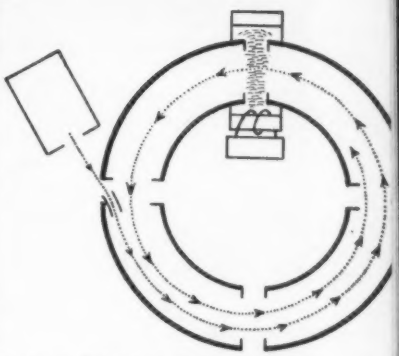
All particle accelerators, including the biggest atom smashers, use the same principle to speed up particles –like electrical charges repel, and unlike charges attract. A negatively charged electron, for example, may be alternately pushed by a negative electrode and pulled by a positive electrode. (For example, in the drawing of the linear atom smasher shown on page 12, anodes 1, 3, 5, etc. may be positive, while 2, 4, etc. are negative.)

The first particle accelerators ever built, in 1932, were actually large-scale versions of a TV tube electron gun. They used much higher voltages, however, to create higher particle velocities. The Van de Graaff generator, which is widely used today, uses friction to build up tremendous electrical charges on a metal ball, in the same way that friction builds static electricity on a comb. The charged ball propels particles down a tube at high speeds.

This type of accelerator cannot shoot particles beyond a certain speed, however, because it can give the particles only a single high voltage "kick." If particles could be "kicked" several times on their way to the target, they could be accelerated to higher velocities.



Powerful cyclotron magnet keeps particles turning in tight spiral. Each time around they get two kicks from high-frequency voltage between dees. Deflection plate pulls beam off to target.



Experiments With Atomics (Thomas Y. Crowell)

Linear accelerator injects high-speed particles into synchrotron's doughnut racetrack. Each time around particles pass through one or more "electron guns" which give high-voltage "kick."

This is the principle of the linear accelerator, a type of atom smasher which accelerates particles in a straight line. The linear accelerator is actually a series of "electron guns," similar to those in the TV tube (except that they are much larger), lined up along the length of a metal tube in which there is a high vacuum. As the particles travel down the tube they receive a "kick" as they pass through each one of the "electron guns."

Theoretically, there is no limit to the number of "electron guns" which can be used in designing a linear accelerator. Since all the "electron guns," have to be placed in a straight line, the greater the number of "electron guns," the greater the final velocity of the particles.

The longest linear accelerator in the world is now being built by the Atomic Energy Commission at Stanford University in California, at a cost of $120,000,000. The accelerator will be housed in a two-mile-long tunnel buried under 35 feet of earth.

Straight Line to Circle

Since linear accelerators grow to such great lengths, it would seem reasonable to try to make the particles move in a circle, instead of a straight line. Thus they could pass through the same electron gun each time around. The particle could continue receiving "kicks" as long as it stays in the circle. It could be accelerated to high speeds in a comparatively small area. Such a machine was built in the early 1930's by Dr. Ernest Lawrence. It was called the cyclotron, and its inventor received the Nobel Prize for his achievement.

In order to achieve its purpose, the cyclotron had to compensate for Newton's first law of motion. This states that a body tends to move in a straight line unless a force pushes it in another direction.

If a ball at the end of a string is twirled in a circle, the string keeps the ball from flying off in a straight line. The force that keeps the ball turning in a circle also keeps the string taut.

Magnet for a "String"

But in the case of twirling particles, no string can be attached to them to keep them from flying off in a straight line. However, scientists found a "piece of string" which would do the job—a magnetic field.

According to the laws of physics, a magnetic field will force a moving charged particle to travel in a curved path. The cyclotron uses a huge magnet to create a very strong magnetic field. The poles of the magnet are two flat parallel discs, a few feet in diameter, and a few inches apart. Between them is the magnetic field.

The magnetic field keeps the beam of particles traveling in a tight spiral between the poles within an evacuated circular can. The can is actually split into two halves, called "Dees" because they look like the capital letter "D." Each dee is alternately

Brookhaven National Laboratory

Aerial view of world's largest synchrotron, at Brookhaven National Lab., N. Y. Half-mile-long circular tunnel is buried under a mound of earth for shielding.

charged positively and negatively, attracting and repelling the particles. They act as an electron gun, giving the particle two strong kicks each time around.

The particles may make thousands of turns between the poles of the magnet before being directed toward a target. Since they will have received two kicks each time around, they will be accelerated to very high velocities.

Racetrack for Particles

As the velocity of the particles increases, centrifugal force increases the diameter of their orbit. When they reach maximum velocity, they will curve out of the "Dees" and smash into whatever has been set up as a target.

The world's largest cyclotron, at the University of California, has magnet poles 15 feet in diameter, and the whole magnet weighs about 3,000 tons. This is about the maximum practical size for a cyclotron.

Larger cyclotrons would require even larger magnets, which would be extremely costly and impractical.

This problem was solved by the invention of the magnetic doughnut, or synchrotron.

The synchrotron has no large single magnet, but uses a great many smaller magnets arranged in a large ring whose diameter may be as great as half a mile. Between the poles of all the small magnets lies the evacuated tube in which the particles will circle. The synchrotron ring is actually a racetrack for particles. The magnets along the track make sure that the particles injected into the ring don't wander off course. A number of "guns" may be located at several spots along the track so that the particles may receive a number of "kicks" each time around.

The Brookhaven synchrotron, which will soon be completed, will have 240 magnets in its ring. Protons may travel as much as 260,000 times around the ring for a distance of 130,000 miles in only one second—creating very large particle velocities.

As the speed of the particles increases, they tend to spiral outwards, unless the force which keeps them circling is increased. In the synchrotron this is done by increasing the strength of the magnetic field as the particles speed up. The magnetic field is increased from zero to maximum in one second, creating a group of high-velocity particles.

To do this requires a tremendous amount of electrical current in the copper coils around the steel magnet core. Every time the magnets are energized they may use almost 7,000,000 watts of power. This power is turned on and off every few seconds. If it were taken directly from the power lines, it would certainly blink the lights in neighboring cities. To avoid this, a motor is used to turn a generator with a heavy flywheel on its shaft. When the magnet is not using current, the motor stores energy in the flywheel, smoothing out the drain on the power lines.

It may seem that particles can be speeded up to infinite velocities in the synchrotron, but Einstein's theory of relativity says this is impossible. According to relativity theory, the mass of the particles increases greatly as their velocity approaches the speed of light. This is not an effect familiar in everyday life. Even a rocket traveling 25,000 miles per hour would show an increase in mass of only about one-millionth of one per cent. However, particles in an accelerator travel at speeds very close to the speed of light, so their mass shows a great increase. For example, an electron accelerated in the two-mile-long Stanford accelerator will have a mass 40,000 times that of an electron at rest.

But from Newton's first law of motion, we know that the greater the mass the greater the force needed to accelerate it. This phenomenon of increasing mass makes it harder and harder for accelerators to push particles as they approach the speed of light. Thus, practical limits are set to the particle velocities which man can create.

To Make Particles Crash

The end is not in sight, however. Bigger machines are being designed for even higher particle velocities. Their purpose is to smash the nucleus with such force that new and presently unknown particles will be created by the impact. Many of these have already been made by the cyclotron and synchrotron. They have been dubbed "strange particles." Some of them exist for only a millionth of a second.

Higher velocities promise to create more "strange particles." One proposed method of reaching such speeds is to aim two high-velocity particle beams directly at each other—creating the same effect as two cars crashing into each other. For a given velocity, such a collision should have twice the force of a single beam of particles hitting a stationary target. This atom smasher will be called a "synchroclash."

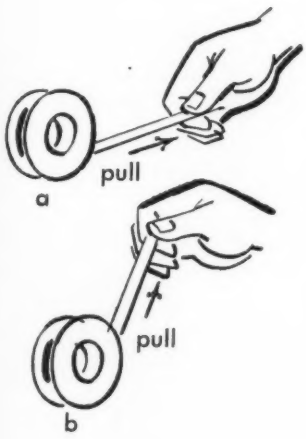
Today the total number of fundamental particles of matter is approximately thirty. This may be the limit, but some physicists feel that the higher-velocity accelerators will reveal many more.

What Happens and Why

By THEODORE BENJAMIN

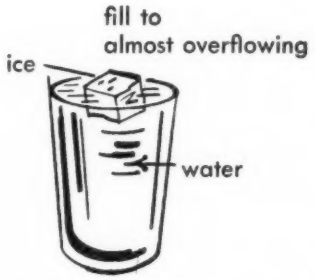
How good are you at predicting and explaining? Below are some experiments you can perform for yourself, but before you do, see if you can predict the outcome and satisfactorily explain why you think your prediction is correct.

1. In a large bowl filled with water float 6 or 8 toothpicks in a pattern radiating from an open space in the center. Dip the corner of a napkin into the middle. What will happen to the toothpicks? Why? Substitute a corner of a piece of soap for the napkin. What happens to the toothpicks? Why?

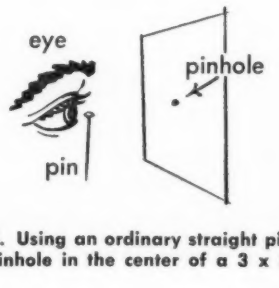


2. Get an empty adhesive tape or typewriter ribbon spool. Attach an 18-inch strip of paper to the center of the spool and roll about half of the tape on it. Stand the spool on the table with the strip leading to your hand from the bottom. Pull the strip at the angle shown in figure A. What happens? Why? Now try pulling as in figure B. What happens? Why?

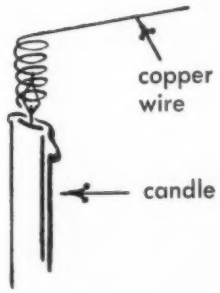
3. Support a yardstick or meterstick on the index fingers of each hand as shown. Draw your fingers toward each other. Will the stick fall off? Why?



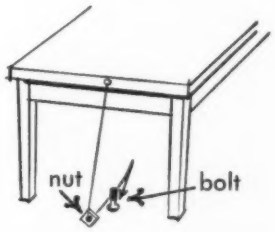
4. Float an ice cube in a glass of water. Fill the glass to the brim with water so that it is just about to overflow. As the ice melts will the water overflow? Why?



5. Using an ordinary straight pin, put a pinhole in the center of a 3 x 5 inch library card. With the left hand, hold the card about 2 inches in front of your right eye and look through the hole toward a lighted bulb. Hold the pin upright with the head uppermost. Now, slowly bring the pin upward between the card and your eye and across your line of sight. Keep the pin close to your eye. Does the image of the pin appear upright or inverted? Why?



6. Insert a coil of copper wire into the flame of a lighted candle as shown. What happens to the flame? Why?



7. Tie a nut to the end of a thread which is attached to a table edge as shown in the drawing above. Stand a bolt on the floor and let the nut swing so that it misses the bolt while swinging one way and hits it on the return swing. Can you do it? Why?

We learn by responses transmitted from cell to cell at 225 miles per hour along complicated, interlocking pathways

Nerves—The Links of Learning

By RICHARD BRANDT

PHYSICISTS predict that one day airplanes will be so automatically controlled that they will not require pilots to fly them. Needless to say, pilots disagree. When, if ever, they say, will we have a machine that thinks like a man?

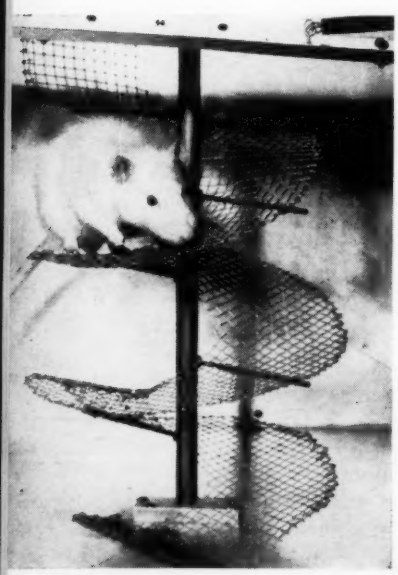
Where else, indeed, can you find an organism stamped with its own individuality, yet made up of millions of individual cells?

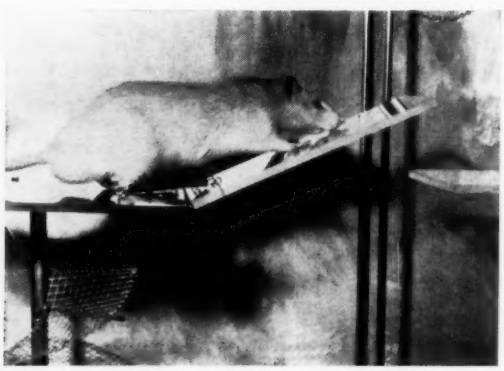
Of course, you do not think of yourself as millions of cells. You think of yourself in terms of hair, eyes, complexion, and other obvious characteristics. You also think of yourself in terms of how you look. Your appearance is important; it makes you different from everyone else. But it is only part of the total you. Another part—equally important, if not more so—is concerned with the way you act or behave as an individual.

Some of the acts you perform are inborn. They cannot be controlled by you. Thus you can't tell your endocrine glands to pour 5 cc. of thyroxin into your blood stream. You don't have to—fortunately. Imagine what life would be like if you had to stop to think about how fast or slow you should breathe, at what rate your heart ought to be beating, or how much of your hormones—and which hormones—to pour into your blood stream from each of your endocrine glands.

Acts such as breathing or blinking, performed with no conscious effort on your part, are inborn reactions known as reflexes. These depend upon nerves for their performance. How do scientists know this? If the nerve responsible for the knee jerk reflex (or any other reflex) is damaged, that reflex cannot take place.

A dramatic event that occurred recently may provide us with new insights into how damaged nerves may be repaired. Two surgeons grafted an almost-severed leg back into place. They attached the arteries and veins to restore the flow of blood in the crushed leg, and fastened the bone together with metal pins. But the crucial test remains: Can they rejoin the severed ends of the sciatic nerve? The sciatic nerve is the largest and longest nerve in the body. It supplies nerve fibers to the skin of almost the entire leg, to the hamstring muscles, and the leg and foot





Barnabel, a white rat, can run an "obstacle course." Running this course requires a whole series of different actions. He has learned these by conditioning. He was conditioned by being fed food pellets after getting past each obstacle. First he was fed only for solving two obstacles, then three, finally a whole series. At left he presses bar that sets off buzzer, then eats. After one minute light flashes: he climbs staircase. Below he runs over drawbridge which closes under his weight. At right he climbs up ladder with 16 steps.

If surgeons can restore the nerve connections between the body and the previously severed leg, it will be the first time this has ever been accomplished.

How Messages Travel

Nerves (such as the sciatic nerve) are made up of bundles of nerve fibers resembling wires in a telephone cable. In motor nerves leading from the spinal cord (which send messages to the muscles), the nerve fibers branch out to various muscles. In sensory nerves (which send messages to the brain), the individual nerve fibers unite to form a large cable which leads to the spinal cord. Sometimes the sensory and motor nerves are bound into one large nerve, as in the arm, for example. If an accident should destroy only the motor nerve fibers, your arm would be paralyzed. But you would still feel sensations in the skin.

Each nerve cable is made up of bundles of branches of nerve cells (neurons). Nerve cells differ from other cells. The nerve cell's body is very small and at one end has a single, thin, protoplasmic thread called an axon. When a nerve cell reacts to a stimulus, the axon carries the message away from that nerve cell to the next. Thus the message, called an impulse, is sped to other nerve cells by means of the axons. At the other end of the cell body are the dendrites. These branch out like twigs to *receive* impulses and carry them *to* the nerve cell body. When the impulses pass from one neuron to another, they come from the axon of the first neuron to the dendrite of the second neuron. In going through a nerve cell an impulse passes from dendrite to cell body to axon to dendrite of the next cell.

Nerve cells which receive impulses and conduct them to the brain are called sensory neurons. Nerve cells that go to the muscles to produce movement are called motor neurons. Each of your nerves is related to a definite area. Each links a specific organ or part of an organ to the larger nerve network. The major nerves are arranged in pairs. This follows the pairing of organs in the two sides of your body.

The gaps between the neurons are connected by "bridges" called synapses. How an impulse gets across these bridges is still in the hypothesis stage among scientists. But so is much of nerve action.

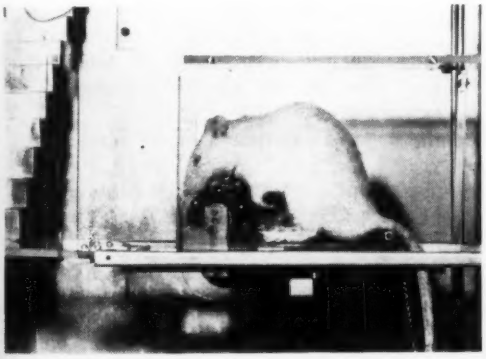
We know that nerves are necessary for reflexes, and by definition reflexes are limited to those acts that do not have to be learned. There are, however, some actions that appear to be reflexes but in reality have been developed by experience.

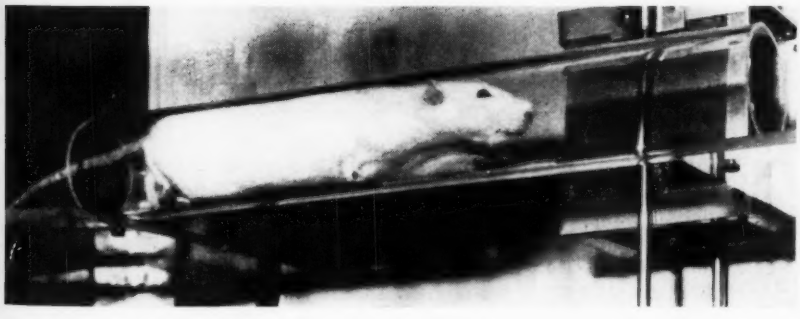
Did your mouth ever water at the sight of a sirloin steak? Then you have acquired a *conditioned* reflex. This was accomplished by performing a certain act (eating) at the same time that you received a specific stimulus (seeing the food). Eventually the two became associated in your nervous system.

Behavior Patterns

Another example: If you snap your fingers each time you feed your dog, the snapping soon becomes associated with the act of eating. Your dog will be conditioned to come for food whenever you snap your fingers. Simple reflexes are inborn, while conditioned reflexes (and habits) are formed behavior patterns.

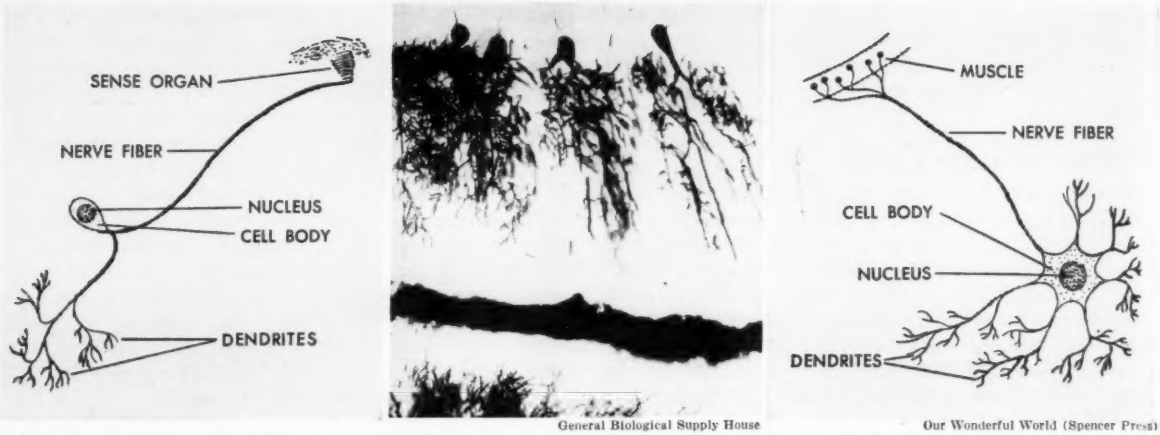
With the development of the nervous system and other parts of the body in the embryo, reflexes and instinctive patterns of response begin to appear in succession. As new nerve connections are formed, new func-





Barnabel encounters a car at left which he pulls to him and pedals across to a flight of steps. He runs up the steps to a tight-fitting glass tube. Below he squeezes through the tube to reach a chain which he pulls with his teeth. Up goes a banner—and sets off the buzzer again. This is his signal to eat again. He rides in an elevator to his bowl of food pellets. Barnabel performs at Barnard College, Columbia University.

New York Times photos



General Biological Supply House

Our Wonderful World (Spencer Press)

Photomicrograph in center shows nerve cells located in the outer covering of the brain. At left is a sensory neuron which carries impulses to the brain or spinal cord. At right is a motor neuron which carries impulses to various muscles.

tions can appear. The development of these new functions is known as maturation. Much of our early behavior usually credited to learning is, in reality, the result of maturation.

All along, in the maturation of reflexes and instincts, we find development of the bridge-like synaptic connections.

Experiments with the tadpoles of certain salamanders have shown that synaptic development goes hand in hand with the maturation of specific behavior patterns. Thus the first sign of a swimming movement in a tadpole is turning of the head to the right or left when the skin of the head is touched. The tadpole will always move its head away from the side on which it is stimulated. This movement appears suddenly at a specific time in the tadpole's development. Until this time, touching the skin of the head produces no response.

Instinctive Responses

To find out what causes this response, scientists studied the sense organs and muscles involved. They found that these were completely developed *before* the twisting response occurred. Sensory neurons were in synaptic contact with the motor neurons—*except* that their dendrites had *not* yet developed. Examination of the neurons after the twisting response occurred, showed that the dendrites of the central neurons had grown out and made contact with the sensory neurons from the skin. Impulses could now pass from the skin on one side of the head across to the muscles on the other side of the body. This accounted for the sudden appearance of a response with a very definite pattern.

The twisting response is only the first step toward the complete swimming response. Each step is marked by new developments of nerve connections. Scientists conclude that the swimming response pattern develops with the growth of the tadpole's nervous system.

How does this relate to human organisms? A young child may have difficulty tying his shoelaces. This may be due to a lack of skill and experience (learning). But it may also be due to the fact that connections in the nervous system are only beginning to form (maturation).

It is difficult to determine which of our functions arise through learning, and which through maturation. In one study tadpoles were anesthetized and kept motionless while growing. At the time when they normally begin to swim, they were put into fresh water. They swam immediately and with complete ease. This experiment suggests that even complicated movements, such as walking or swimming, may appear without the aid of learning.

Maturation enables most organisms to develop a system of *instinctive* responses. These responses enable an organism to adapt to its environment. In the human species and among some of the other higher mammals, there are forms of adaptation that are other than instinctive. Unlike lower organisms, human beings and other higher animals inherit the ability to change their behavior to fit a special situation. They also have the ability to learn, which enables them to *retain changes* in their behavior, and to use them again in the same or similar situations.

How We Learn

How does learning occur?

Nerve impulses encounter varying degrees of difficulty in crossing synapses. (It is believed that electrical and chemical factors account for this difficulty.) Each response to a situation has a "threshold" (not unlike a doorway's *threshold*). It may be easy or difficult for the response to get across.

Many stimuli may act upon you at one time. These stimuli may call for entirely different types of behavior reaction. For example, in a particular situation one stimulus may call for approach, the other for retreat. (A mailman may have to deliver a letter —approach—to a house that has a hostile dog—retreat.) Usually, one of these conflicting stimuli will generate the stronger impulses. The *dominant* stimulus is able (through its set of impulses) to block the weaker set. It absorbs the weaker impulses and therefore brings about its own response.

If a situation is repeated over and over, another type of response takes place. The weaker stimulus not only strengthens the stronger stimulus, it *substitutes* for it. For example, if a child is given a doll, and at the same

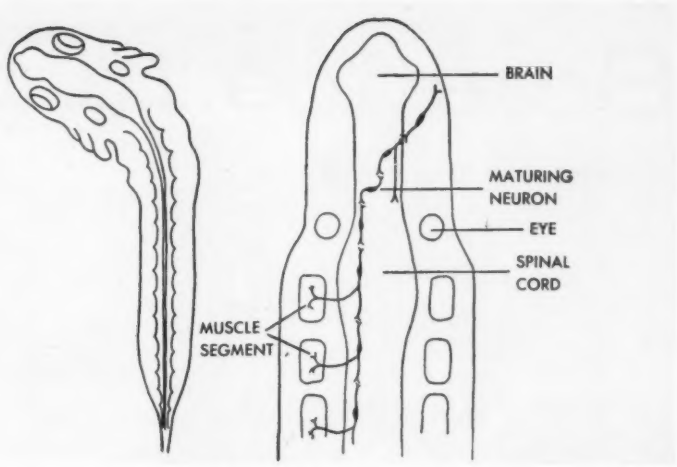
time a loud noise is sounded causing the child to cry, the child will start crying at the mere sight of the doll, even though there is no sound. The doll becomes a conditioned or substitute stimulus for the loud noise. Crying has become a *conditioned response*.

The simplest kind of learning, involving movement, has been explained in terms of the conditioned response.

Learning by Conditioning

The first stage of learning is one of trial and error. For example, when you first learn to play a musical instrument, you hit many wrong notes. When you learn to ride a bicycle, you fall off at first and then zigzag in many directions.

During this period many separate conditionings are formed. Some of these conditionings you later drop. Others you keep. The ones you retain form a pattern of behavior. This pattern will unwind itself in the proper order, because each movement has the necessary internal cues to put the next movement in motion.



Human Organism (Harper & Bros.) from Coghill's Anatomy (Cambridge Univ. Press)

Tadpole touched on side of head gives a twisting response, away from side that is stimulated. Response comes with growth of dendrites of the central neurons.

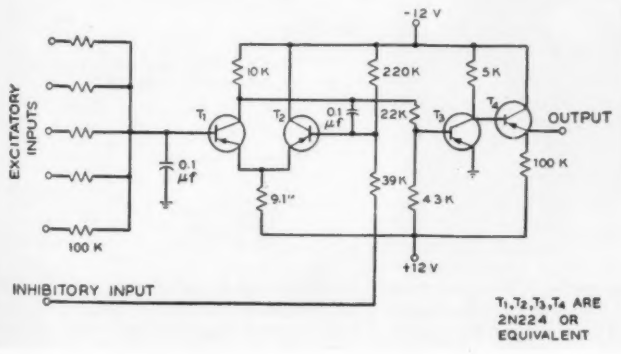
Eventually you learn to play a musical instrument or to ride a bicycle. After many trials, you begin to strike the right notes; you steady yourself on the bicycle. You have *learned* to do something. You have learned by conditioning. It is the ability to learn (and recall) that gives man his distinctive place in the animal kingdom.

Man is the only creature on earth capable of reading this page. This skill, as does every one of your skills, depends upon learning. Your capacity to learn—and to use this learning—determines the kind of life you will lead.

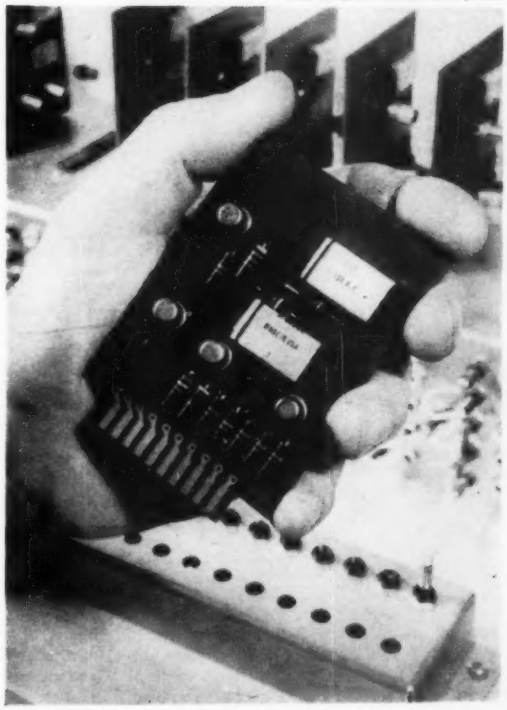
ARTIFICIAL NERVE CELL

A simple transistor circuit to imitate action of a living nerve cell has been developed by L. D. Harmon of Bell Telephone Laboratories. He has assembled many such cells into experimental networks that imitate some nerve functions of the eye and ear.

The cell is put together on a three-by-four-inch, printed-circuit card. Circuit is shown below. The electronic cell delivers a series of electrical pulses when stimulated, just as does a living nerve. It also can show fatigue; that is, slow down under prolonged stimulus. The cells provide a new avenue of approach for scientists studying nerve functions.



Bell Telephone Laboratories photos



Science in the news

Recipe for Diamond

Recipe for a diamond: Take a dash of pure graphite, and add to it a pinch of metal such as chromium, manganese or iron. Mix thoroughly and place in pressure chamber, raising pressure to 1,800,000 pounds per square inch.

While the mixture is under pressure, heat to 4,400 degrees F. for several minutes. Shut off heat and pressure and allow to cool.

Result: Half a thimblefull of man-made industrial diamonds—worth about $6,500 a pound.

This recipe, cooked up by General Electric scientists as early as 1955, was until recently a well-kept government secret. The vital ingredient, recently revealed, is none other than the added pinch of metal. Without the metal, artificial diamonds would be more difficult to make. They would require pressures of 3,000,000 pounds per square inch and temperatures of 7,000 degrees F. No materials we have at present could produce and hold such extremes of pressure and temperature.

However a dash of chromium, manganese, iron, cobalt, nickel, ruthenium, rhodium, palladium, osmium, irridum, or platinum makes all the difference. It reduces the required pressures and temperatures to the point where the manufacture of diamonds becomes practical.

Graphite, the starting material, and the finished diamond are both carbon. But the carbon atoms in a diamond are packed much more closely together. The graphite carbon atoms naturally resist being squeezed together. They refuse to move into a closely-packed diamond arrangement unless tremendous heat and pressure are exerted on them. The added molten metal acts as atomic "grease." It undermines the resistance of the graphite atoms, and allows them to be squeezed together.

When the graphite and metal mixture is placed under heat and pressure, the metal becomes liquid and dissolves the graphite. The carbon atoms can then rearrange themselves in the formation of a diamond, and exclude the metal as slag.

The entire operation takes place in a cavity the size of a pencil eraser. (And the graphite is the same that you find in your pencil.) The material is heated by passing an electric current through it. The pressure is applied by a huge hydraulic press. Such pressures—1,800,000 pounds per square inch—occur in nature at a depth of 240 miles below the Earth's surface.

The diamonds that emerge are about a tenth of a carat, or a thousandth of an ounce. To the naked eye they appear very much like grains of sand. A microscope reveals their diamond crystal structure *(see photo on page 21)*.

The temperature at which they are formed determines the shape of the diamonds, and their color. They vary from black at low temperatures, through dark green, light green, and yellow, to white at the highest temperatures.

The artificial diamonds are used exclusively for industrial grinding, cutting, and polishing. They are unsuited for jewelry because of their very small size and poor coloring. The United States uses about two tons of industrial diamonds yearly. Although they cost $6,500 a pound, this is only a fraction of the cost of large, pure gem stones.

Current from Hot Gas

Future space vehicles may obtain their electric power directly from the hot blast of the rocket's exhaust gases. They may use a revolutionary type of electric power generator, recently developed by General Electric. This converts the heat of a stream of very high temperature gas directly into electrical energy—without moving mechanical parts.

The new generator is similar to conventional generators in only one respect—it is based on the movement of an electrical conductor through a magnetic field. Instead of the rotating wires and magnets of a conventional generator, it uses a high-temperature ionized gas as the electrical conductor.

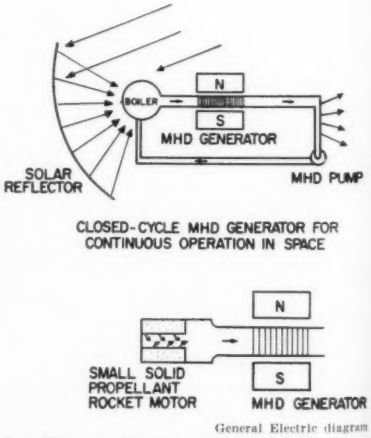
Since the stream of gas is the only moving part, there is no friction to overcome. This means greater efficiency in converting heat to electrical energy. It is estimated that the gas-stream generators may convert as much as 40 or 50 per cent of their heat energy into useful electrical power. A conventional mechanical generator may convert only 35

General Electric photo

Motionless electric generator for rockets draws power directly from engine exhaust gases, which pass through vertical tube between two round electromagnets.

General Electric photo

Heart of the generator is a quartz tube (white section) through which rocket gas passes. Two blocks are magnet pole pieces. Dowel is a graphite electrode.



General Electric diagram

Satellites could use solar or nuclear heat to provide continuous electric power (*top*). Rocket engine (*bottom*) would provide one short strong burst of power.

per cent of its energy input into electricity.

The new type of electric power generator works on the principle that at very high temperatures, about 5,000 degrees F., the molecules in a gas ionize, or break up into charged particles—negative electrons and positive ions. At such temperatures, the violent motion of the molecules is sufficient to ionize the gas.

Normally, the negative and positive particles are all mixed up in the ionized gas. To separate them, scientists used an electromagnet to create a magnetic field around the gas stream. As the ionized gas passes between the poles of the magnet, the magnetic field forces the negative electrons in one direction, and the positive ions in the opposite direction. The magnet actually splits the gas stream into two streams—one of negative electrons and one of positive ions.

The difference in potential between the two gas streams is about 30 volts. It is now a simple matter to place two graphite electrodes into the gas—one in the negative stream and one in the positive stream. If a wire connects the two electrodes, current will flow.

An experimental model of the generator produced 1 kilowatt of power for about five seconds.

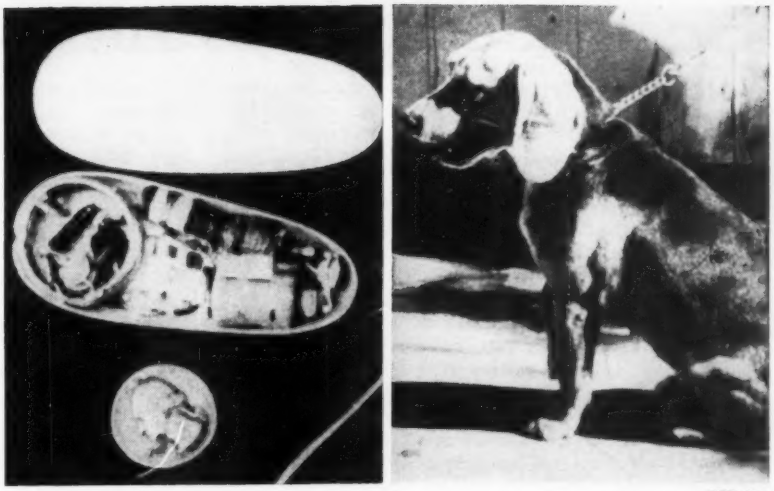
This means of producing electric current has been given the tongue-twisting name of magnetohydrodynamic (MHD) power generation. "Magneto" refers to the magnetic field used; "hydro" refers to a fluid, or in this case, a gas; and "dynamic" refers to motion. Since a high-temperature ionized gas is usually called a plasma, this could also be called a plasma generator.

The MHD generator is an efficient source of electrical power for space vehicles. It could provide a brief burst of power during the time a rocket's motor is spewing forth hot ionized gas.

The MHD generator could also tap the sun's energy to provide continuous electrical power in space. A solar reflector could concentrate heat on a boiler, creating temperatures high enough to ionize the conductor gas.

Future space ships may also use two other methods of producing electricity without mechanical generators. One is the chemical fuel cell, which draws electricity from the chemical reaction between different gases. The other uses the motion of electrons in semi-conductor crystals to generate electricity directly from heat.

It may well be that the powerhouse of the future will be a silent, motionless place, with no hum of high-speed machinery to betray the powerful forces at work within.



UPI photo

A beagle named "Orbit" (*right*) with a two-ounce radio sewn inside his chest (*left*) may join the first astronaut in his lonely journey through space. Radio would monitor dog's heart, blood, and breathing to warn of danger in space.

Magnetic Shell

Scientists have found that atomic explosions can create a shell of magnetic waves around the Earth. These unusual magnetic waves flow only in an electrically conducting gas, such as the ionized air in the ionosphere. Hence, they are called hydromagnetic waves.

After an explosion, hydromagnetic waves are trapped briefly in a spherical shell surrounding the Earth. This shell is from 1,200 to 1,800 miles above the Earth's surface. *(See drawing on page 9.)*

The hydromagnetic shell is the second energy shell observed after an atomic explosion. The first shell was found immediately after the Project Argus explosions, held over the South Atlantic in 1958. That shell was made up of electrons, released through the explosion. The electrons flowed along the Earth's magnetic lines of force.

The second shell, of hydromagnetic waves, does not follow the Earth's magnetic field, but forms a sphere around the Earth. It was discovered by examining the records of magnetic signals at scientific stations in Arizona, Sweden, Iceland, Maine, New Jersey, and the Azores.

These records showed that the hydromagnetic waves had not traveled along the Earth's magnetic lines of force, but along a much shorter path. Scientists then calculated theoretically how long it would take for hydromagnetic waves to travel between the observation stations if they followed a great circle route around the Earth. (A great circle route is the shortest distance between two points along the surface of a sphere.)

The times calculated theoretically and the times recorded at the observation stations coincided almost identically—strong evidence that the theory of a spherical shell of hydromagnetic waves surrounding the Earth was correct.

The scientists detected the hydromagnetic waves with giant coils of wire—somewhat like the loop antenna on an ordinary radio.

Fossil Bird

The carbonized imprint of a bird, 35,000,000 years old, is being studied at the New York Botanical Garden. The investigator is Dr. H. F. Becker, a paleobotanist. Dr. Becker found the imprint on the site of a dry gulch about 25 miles from Virginia City, Montana.

The bird fossil was discovered in the same bed as plants that have already been positively identified as belonging to the late Oligocene Age. Thus Dr. Becker was able to estimate that the fossil is 30-35,000,000 years old.

GE photo

Diamonds made of graphite in lab show crystal structure under microscope.

Science in the news

Volcano Erupts

The people of Hawaii have been living atop a volcano ever since the first Polynesian canoe touched shore, bringing the island's original inhabitants.

The danger of life atop a volcano is usually ignored by the Hawaiians, but the recent eruption of Kilauea Iki crater on the island of Hawaii was a dramatic reminder of the original formation of the islands.

Although Kilauea Iki is one of the smaller volcanoes in Hawaii, it managed to gush molten lava 1,000 feet into the air. The lava spurted from the floor of a mile-wide, 600-foot-deep crater, which had been created by a much larger eruption in 1868.

The blast and eruption were preceded by weeks of minor tremors in the area. They were too weak to be noticed by the islanders, but were recorded on seismographs, sensitive instruments which detect vibrations in the Earth's crust. Scientists deduced from the seismograph records that there would be no explosions with the eruption, as happened in the great eruption of 1868.

At that time, Hawaii's Mauna Loa, the largest active volcano in the world, erupted violently. Earthquakes created a 40-foot tidal wave which swept over the coast, killing 81 persons. In a later explosion of Mauna Loa, the army used bombs to divert the volcano's flow of lava into isolated areas.

There are only two active volcanoes in Hawaii, but the whole chain of islands is of volcanic origin. The islands are really the tips of massive volcanoes which rose from the floor of the sea millions of years ago.

The volcanoes were created by molten lava seeping through a 2,000-mile-long crack in the sea floor, then cooling into volcanic rock upon touching the waters of the sea. The only parts of the islands which are not of volcanic origin are those created by the action of coral polyps, tiny animals which built up rock-hard reefs in the warm shallow waters around the islands.

Continental Bridge

The ice-covered continent of Antarctica may once have been joined by land to Australia. A New Zealand research team, exploring in Antarctica, uncovered new evidence to support this theory. They found rock samples in Antarctica that were the same age as similar rocks found in Tasmania, a large island between the Antarctic and Australia.

This particular type of rock, called dolerite, was formed at a certain stage in the Earth's development. This evidence indicates that Australia and Antarctica may have been joined at the time the dolerite rocks were formed, with Tasmania part of the bridge.

UPI photo

River of lava flows down slopes of Kilauea Iki volcano, Hawaii, in recent eruption. Lava flows from cracks in crater's sides to floor of crater, 300 feet below. Photo was taken from crater's rim. Hawaiian islands are actually peaks of volcanoes rising from ocean floor. Volcanoes still have shafts of molten lava.

Space Weather Station

An orbiting satellite may soon keep a weather eye on the Earth's cloud cover with a pair of cloud-scanning television cameras. The satellite, known as Project Tiros, should give weathermen a global picture of the Earth's weather and allow them to make more accurate weather predictions.

Both the Vanguard and Explorer satellites, sent up earlier this year, had cloud-scanning cameras, but they covered only limited sections of the Earth. The photos they took, however, were useful in spotting storms forming in untraveled areas of the oceans.

The study of rocket pictures has also revealed that cumulus clouds often form in "streets" parallel to the wind, but of such vast size that they were never recognized from the ground. Also, the satellite weather pictures could be compared with local ground weather observations. Thus it was possible to relate global weather changes with local wind, storm, and cloud conditions.

Project Tiros should send back enough TV pictures to reconstruct cloud patterns over a large portion of the Earth. Its orbit will carry it over all or most of the United States. The satellite will be spinning like a rifle bullet to stabilize it so that it will remain pointed in the same direction.

The two cameras, aimed out one end of the satellite, will be able to scan the sunlit portion of the Earth only at certain times. When a computer indicates that the right moment has come, a radio signal will be sent from the ground to the satellite, turning the TV cameras on. The images will be stored on magnetic tape and broadcast to stations in Hawaii or New Jersey when the satellite passes over them.

The received signals will appear on a television screen and be photographed. All the pictures will be fitted together, like a jigsaw puzzle, to give a complete view of the areas scanned.

Project Tiros is actually the first step in a plan to send up bigger and more complex weather satellites. Future satellites will be aimed at the Earth at all times, to deliver a continuous picture of the Earth to ground stations. Also, infrared cameras may be used to detect cloud masses on the night side of the Earth. Clouds of warm air would show up brightly on cameras sensitive to infrared light.

Ultimately, a complete weather observation station will be sent into orbit, with a combination astronaut-weatherman to operate its elaborate equipment. It will be an even lonelier job than that of lighthouse keeper.

Heartbeat Heredity

Medical science has new evidence to work with in studying the hereditary aspects of heart disease. It is now known that there are four types of normal heartbeats.

Two types of heartbeats were previously thought to be symptoms of serious heart disease. These were reported to be normal, according to the findings of Dr. J. Marion Bryant, New York University Post-Graduate Medical School, and Dr. R. Richard C. Bozian, of Nashville, Tennessee.

The four variations of heartbeats will supplement blood typing as a tool for the study of heredity. The discovery will also aid in identifying family relationships and in studying the anthropology of various races.

By using an electrocardiograph, the doctors were able to detect variations of heartbeat action that could not be picked up by a stethoscope. (The electrocardiograph is an electronic device that makes a graph of heart action.)

Heartbeat variation seems to follow the rules of heredity that govern eye color. When both parents are blue-eyed, their children almost always are blue-eyed. Blue (b) is recessive.

bb + bb = bb, bb, bb, bb

Brown-eyed parents may have children whose eyes are blue or brown. Brown (B) is dominant.

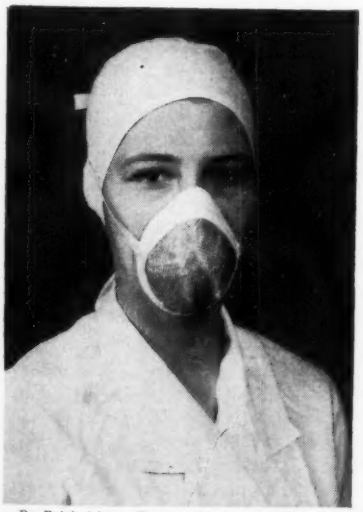
Bb + Bb = BB, Bb, Bb, bb

The heartbeats of 45 families (302 individuals) recorded on electrocardiograms indicated variations at two stages of heart action. In each case there was a dominant and a recessive form, making a total of four types.

Region, age and sex had no effect on the distribution of the four types of heartbeat in healthy individuals.

The two heartbeat types previously thought to be "abnormal" have caused some individuals to become invalids, or to be denied life insurance at regular rates.

Drs. Bryant and Bozian report that their findings are tentative and that more extensive investigations have to be made.



Dr. Ralph Adams, Huggins Hospital, Wolfboro, N. H.

New surgeon's mask contains fiberglass filter that traps 95 per cent of germs in wearer's breath, in contrast to 10 per cent efficiency of mask now in use.

Syncillin

Antibiotics have caused a revolution in the treatment of bacterial infections. Since 1943, when penicillin first came into widespread use, many millions of lives have been saved by antibiotics. These are substances which inhibit the growth of disease-causing bacteria. Antibiotics are produced by living organisms found in the soil.

When scientists discovered antibiotics, they found that they could use the secretions of one type of germ (harmless to man) to destroy a harmful type of germ. This worked fine until it upset "the balance of nature" in a germ population. With one type of harmful microorganism eliminated, certain other harmful germs ("natural enemies" of the first type) were able to thrive.

These were not affected by the antibiotic. Infections caused by such resistant germs have been on the increase, along with allergic reactions to antibiotics.

The need to find new and better antibiotics was urgent. By 1958 nineteen different antibiotics had been developed in the United States. A treasure hunt extending across 58,165,000 square miles of the earth has been going on for the one pinch of soil which might contain the source of a valuable new antibiotic.

At the same time, another kind of search has been in progress—in the laboratory. To many scientists, one of the best hopes for continued success in the war against microbes seemed to lie in finding a way to improve penicillin. They sought to synthesize the compound, change part of its structure, and then develop new compounds which might have the natural drug's basic good qualities, coupled with needed new characteristics.

Bristol Laboratories reports that it has developed the first synthetic penicillin for medical use. The new compound has been named Syncillin.

" So potent is this new penicillin tablet," said Dr. Amel R. Menotti, Bristol vice-president and scientific director, "that it promises to make the penicillin injection or 'shot' obsolete."

Syncillin is the result of a complex chemical procedure for creating variations of penicillin never before possible. Hundreds of these synthetic penicillin compounds have been formulated and tested.

To produce the new drug, a synthetic chemical chain was added to the basic structure of the original penicillin, which is still made by microbes (molds). (Chemically the new drug is potassium alphaphenoxyethyl penicillin.)

Dr. Menotti claims that preliminary tests indicate that Syncillin can provide effective antibiotic action in the bloodstream at levels twice as high as those obtained with the same dose of the best forms of penicillin now available.

It is claimed that most persons sensitive to the most commonly used form of penicillin (g) will not be sensitive to Syncillin.

Space Radio

Radio astronomers have appealed for radio silence in a number of frequency bands, to enable them to listen more closely to the noises of the universe (*see Nov. 4 issue of Science World*).

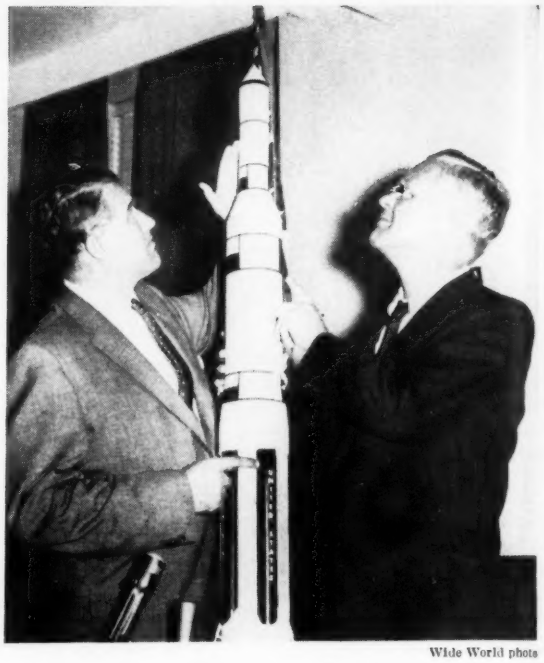
A U.S. proposal to reserve 17 frequency bands for the exclusive use of radio astronomers was presented at a recent meeting of the International Telecommunications Union. Man-made radio signals would be prohibited on these frequency bands. Thus radio astronomers could tune in on the cosmos without encountering interfering noises made on the Earth.

UPI photo

Surgical stapler quickly ties major blood vessels and stitches the heart and lungs. Staples are of chemically inert vitallium metal, and remain in the body.

today's scientists

Wernher von Braun
SPACE PROPHET



Dr. Wernher von Braun *(left)* presents model of Saturn space vehicle to Roy Johnson of Defense Department. Engine of Saturn will develop thrust of 1,500,000 pounds.

Wide World photo

THE U.S. Army's top rocketeer, Dr. Wernher von Braun, has dedicated his life to what he calls man's "greatest adventure": the conquest of space.

Dr. von Braun's enthusiasm for space was kindled by his mother, an amateur astronomer. "For my confirmation," he has said, "I didn't get a watch and my first pair of long pants, like most Lutheran boys. I got a telescope."

With his mother as a teacher, the young German began to study the constellations and planets in the night sky over his home town of Wirsitz, East Prussia (now part of Poland). His interests soon turned to space travel and the rocket engine—the only engine that can function beyond the Earth's atmosphere in the vacuum of space.

For example, a propeller-driven plane is moved forward when its prop bites into the air. The oxygen in the air also enables the plane's engine to burn fuel. The rocket engine carries its own oxygen—either mixed with its fuel or in a separate tank. It is moved forward because for every action (the rocket engine "thrust") there is an equal and opposite reaction (the forward motion), and the two are directed along the same straight line. This, you will recall, is the principle described in Sir Isaac Newton's Third Law of Motion, stated in 1687.

Von Braun was barely in his teens when he looked into a rocket textbook. Suddenly his face fell. Page after page was covered with complicated mathematical equations. And von Braun despised math. He had even flunked it at school. "But I decided that if I had to know about math to learn about space travel and rocketry, then I'd have to learn math," says von Braun.

In the years ahead, von Braun studied engineering at the institutes of Berlin and of Zurich, Switzerland. By the time he received his B.S. degree in engineering in 1932, he had joined a group of amateur rocketeers.

The junior birdmen used an abandoned ammunition dump outside Berlin as their "Cape Canaveral." Their most powerful rocket motor developed a thrust of 13 pounds. It kicked a small rocket to an altitude of one mile.

How Problems Were Solved

The activities of the Berlin rocketeers quickly came to the attention of the German army. The army was searching for a way to get around the terms of the Versailles Treaty, signed by a defeated Germany at the end of World War I. The treaty listed all the long-range weapons prohibited to the Germans. But rockets were not mentioned. Von Braun was only 20, but he was hired as top civilian specialist of the army's fledgling rocket team.

Von Braun's first project was the construction of a stand on which rocket engines could be tested to produce useful information. For example, to determine fuel consumption from second to second, scales were installed to record the weight of the fuel tanks. Other instruments measured the temperature of the engine.

The rocketeers soon discovered that the hottest part of the engine was its "throat"—the narrowest section in its exhaust pipe. Von Braun cooled the throat with droplets of alcohol from the fuel system. The alcohol evaporated and formed a protective cooling film.

The year 1934 was a banner one for von Braun. In addition to logging his first successful shoots (6,500 feet—thrust of 650 pounds) he was awarded a Ph.D. degree in physics by the University of Berlin.

At the rocket research center of Peenemuende on an isolated island in the Baltic Sea, von Braun began to build larger and better rockets. But as rockets became more "sophisticated," new problems arose. One problem was stability. To help keep a rocket on course as it rose through the atmosphere, vanes (or fins) had been added to its tail. Like the feathers on an arrow, the vanes stabilized the rocket, and kept it from wobbling.

The tail vanes worked—but only as long as the rocket was in the lower atmosphere. Above an altitude of 10 miles—in the thinner air of the upper atmosphere—the vanes lost their "bite."

Dr. von Braun decided to put *internal* vanes on the rocket. The internal vanes extended into the path of the rocket engine's exhaust. Thus they acted against the *exhaust* stream—rather than against the *air* stream. The rocket would now maintain its stability as long as the engine was firing—which was long enough.

Next came another problem con-

(Continued on page 29)

tomorrow's scientists

Project: Isolation of the Enzyme Sucrase

Student: **David Lloyd**
Streator Township High School
Streator, Illinois
Science Achievement Awards Entry
Teacher: **Arthur Ritcher**

WHILE I was in the seventh grade, my science teacher asked me to make a report on the subject of enzymes. These substances immediately caught my interest.

When I started high school, I decided to make and concentrate an enzyme solution for my project in the science fair sponsored by the Illinois Junior Academy of Science each spring. I picked the enzyme zymase which breaks glucose down into alcohol and carbon dioxide. I had no idea how to go about accomplishing my goal, but my general science teacher found a method of preparing an autolyase of the enzyme sucrase.

This enzyme has many properties which make it suitable for my work. It can be obtained from yeast which can be bought in any grocery store. Its presence can be readily detected due to its action on non-reducing sugars to form glucose and fructose, which are reducing sugars. Since very little work has been done with this enzyme, it gave me a chance to use ideas of my own.

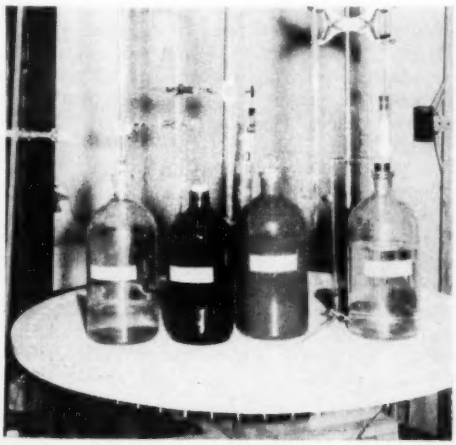
Before I began my experiments I did some armchair research on sucrase and enzymes in general. The majority of this information came from *Practical Physiological Chemistry*, by Hawk and Bergeim.

Extremely Selective Enzyme

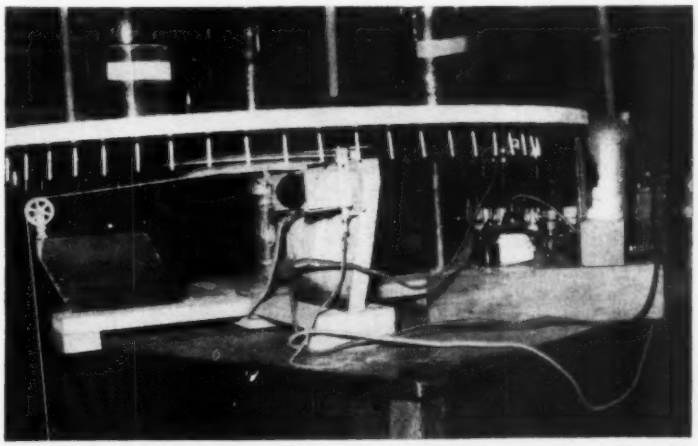
First of all, sucrase is a member of a group of enzymes known as carbohydrases. It catalyzes the reaction in which sucrose is hydrolyzed to an equimolar mixture of glucose and fructose known as invert sugar. (A chemical process of decomposition involving the addition of the elements of water.) As in most cases, this enzyme is extremely selective. It attacks only the alpha D glucoside linkage and will not hydrolyze even the closely related optical isomer beta glucose. Enzymes are thought to be closely related to proteins and as such are sensitive to both their chemical and physical environment.

As a general rule enzymes are inactivated at temperatures above 60° C., although they may regain their activity on cooling. Enzymes are not, however, inactivated by temperatures as low as 0° C. Neglecting inactivation, we can say that enzyme activity approximately doubles for each 10° C. rise in temperature. Thus the optimum temperature for an enzyme is a happy medium between inactivation and thermal increase in activity. This point lies between 30° C. and 50° C, for most enzymes.

The pH range (pH expresses both acidity and alkalinity) for the enzyme sucrase is between 3 and 7 and the optimum is between 4 and 6 (slight acidity). Heavy metallic ions strongly inhibit enzyme reactivity even in minute quantities. However, this may be combated by adding hydrogen sulfide

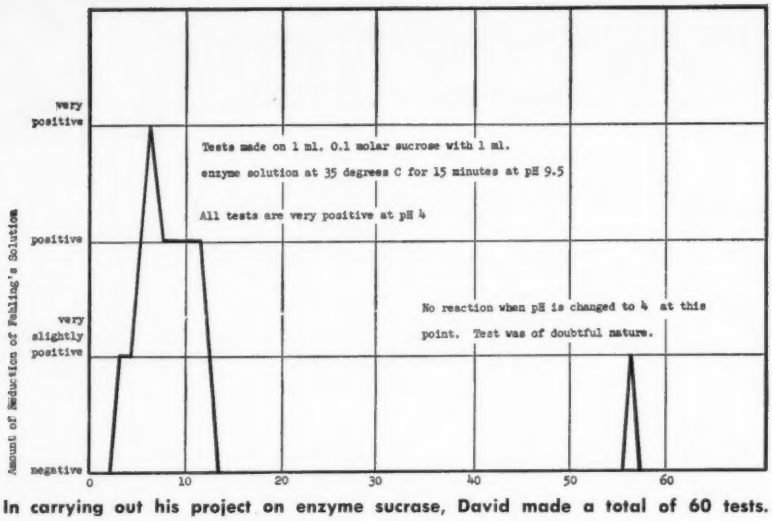


In this topside view of David's chromatographic table, bottles containing chemicals are shown.



Underside of table shows 60 test tubes around perimeter. Table is driven by weight which is controlled by escape mechanism, controlled by photocell.

TESTS ON ENZYME SOLUTION


very positive
positive
very slightly positive
negative
Amount of Reduction of Fehling's Solution
Tests made on 1 ml. 0.1 molar sucrose with 1 ml.
enzyme solution at 35 degrees C for 15 minutes at pH 9.5
All tests are very positive at pH 4
No reaction when pH is changed to 4 at this point. Test was of doubtful nature.
0
10
20
30
40
50
60

In carrying out his project on enzyme sucrase, David made a total of 60 tests.

or hydrogen cyanide. Certain salts may actually promote an enzyme reaction.

In solutions containing high concentrations of glucose and fructose, small quantities of sucrose are formed when sucrase is present. Thus we see that enzyme reactions are reversible. The equilibrium reached is the same whether one starts with glucose and fructose or sucrose.

After this preliminary research I set to work to prepare a sucrase solution. The method given by Hawk and Bergeim in *Practical Physiological Chemistry* was as follows. One hundred grams of yeast are suspended in 10 ml of toluene, which kills the yeast, making the extraction of the enzyme possible. Then 100 ml of water are added and the mixture is thoroughly mixed and centrifuged. The fluid is poured off and the residue is saved and mixed with 100 ml of water saturated with toluene. All solutions are kept at about 30° C.

Preparing Sucrase Solution

The next day the mixture is diluted with four volumes of water and 1.0 M acetic acid is added until methyl red indicates a pH of 3.5 to 4. This solution now contains the enzyme. The yeast cells are removed by first centrifuging and then filtering with suction. The solution is neutralized with ammonium hydroxide using brom ceosol purple as an indicator. The solution must be kept refrigerated.

To speed things up and increase the concentration of sucrase, I simplified this process considerably. The toluene suspension is made as usual and let stand for 48 hours at 30° C. Then it is diluted with five volumes of water and the pH is brought to 3.5-4. The mixture is set aside for 72 hrs. at 30° C., then filtered with suction to remove the yeast, and refrigerated.

Both the centrifuge and the incubator were homemade equipment. I made the centrifuge out of a single phase quarter horsepower motor mounted on end in a heavy wooden box. I obtained the centrifuge head from an old discarded centrifuge. The incubator is a crate box which I insulated and equipped with a 60 watt light bulb and a furnace thermostat.

After I had prepared a solution I proceeded to test it to find out whether it was active. I allowed one ml of yeast extract to act on one ml of 0.1 M sucrose solution at 70° C. for 5 minutes. Both glucose and fructose, the products of the enzyme reaction, are reducing sugars. This activity is due to the presence of the aldehyde group in glucose and the ketone group in fructose. However, in sucrose these two sugars are joined through their aldehyde and ketone groups. Thus the sugar is inactive and will react negatively to a Fehling's test. If any of the sucrose in my test solution was hydrolyzed, the Fehlings test would be positive.

I also ran control tests to discover such things as: does my yeast extract contain reducing agents? does my sucrose solution contain any glucose or fructose? Both of these are negative. I, therefore, assumed that my extract did contain the enzyme sucrase.

I then attempted to concentrate my solution. I used three principal methods: evaporation, freezing, and dialysis (separating by means of unequal diffusion through certain membranes). I placed about 25 ml of my solution in a large evaporating dish, let it stand for several days, then tested it for enzyme activity. The test was negative. I then froze some of my solution. As ice crystals formed, the dissolved materials concentrated in the unfrozen portion. This lowered the freezing point of the concentrated solution which is formed, causing it to remain fluid. When I poured off the liquid and tested it, I found that it tested positive.

In the dialysis experiment I hung a dialyzing bag in open air with enzyme solution in it. The water and inorganic salts pass through the bag and the enzyme and other proteins are left behind. The only dialyzing membrane which I could find was an animal membrane and after several days it began to stink. The experiment was discontinued at the suggestion of the instructor in whose room I was working.

Work in Sophomore Year

When I started work in my sophomore year I had been reading about chromatography and the use of adsorbents, so I postponed my work on a quantitative sugar test to experiment with chromatography. In *Practical Physiological Chemistry* I learned that kaolin and aluminum hydroxide adsorb enzymes, which can then be eluted (washed out) with a dilute solution of ammonium hydroxide. I began to experiment with various adsorbents, not only kaolin and aluminum hydroxide, but also silicon dioxide, cellulose of two types, and sodium aluminum silicate. I ran my first tests using the material simply as adsorbents and not in a column.

My test procedure ran as follows: I introduced about 1.0 ml of the adsorbent into 15 ml of my enzyme solution and mixed the two thoroughly, letting them sit overnight. The solutions were then centrifuged and the clear solution tested for enzyme activity. Then I washed the adsorbent thoroughly to rid it of unadsorbed traces of enzyme, and tested it for enzyme activity. If the adsorbent tested positive, I attempted to elute the enzyme from the adsorbent with both acetic acid and ammonium hydroxide at pH 4 and pH 8.

I then tested the elutant for enzyme activity. My first test was on kaolin, which adsorbed part of the enzyme as evidenced by a positive test with kaolin. However, I could not elute the enzyme with either acetic acid or ammonium hydroxide. I received the same results with a kaolin which I treated with hydrochloric acid to neutralize any bases present, a commercial prepara-

tion of aluminum hydroxide, and some aluminum hydroxide which I precipitated from aluminum sulfate.

When I tried the silicon dioxide and cellulose, which I prepared from sawdust and sulfuric acid, I found that these substances did not adsorb any enzyme. However, I ran tests on cellulose and sodium aluminum silicate, which I precipitated from an ammoniacal copper solution known as Schweitzer's solution. I found that these adsorbents not only adsorbed the enzyme, but also that I could get a positive test on my elutants, which indicated that they were enzymatically active. From this information, I concluded that these materials would make a good chromatographic column packing.

A Variety of Samples

But before I could do any chromatography experiments, I needed a way to collect a variety of samples. I had to make what I call a chromatographic fractionating table. This piece of apparatus is a large circular table containing sixty test tubes around the perimeter. It is driven by a weight which is controlled by an escapement mechanism, which in turn is controlled by a photocell.

As the elutant fills the test tube the meniscus (curved upper surface of the liquid) rises until it is in line with a beam of light directed on a photocell, at which point it acts as a lens and bends the beam away from the photocell. The photocell is then triggered and a surge of current is supplied by a capacitor which releases a catch, causing the table to revolve to the next test tube.

I had considered sending a dye through with the enzyme, so that I could mark the position of the enzyme in relation to the dye but this relationship does not remain constant so I discarded that idea. At this point I again concluded my work until the next school year.

The Third Year

The first thing I did when I started work the third year was to mix up an enzyme solution and set up my chromatographic fractionating table from last year. Then, using sodium aluminum silicate, I set up a column and ran some enzyme solution through it. I used pH 4 acetic acid as an elutant but due to insufficient washing the solution came out of the column at pH 9.5.

The next series of experiments which I did involved precipitating the enzyme from solution with an organic solvent. I tried both alcohol and acetone. I decided to use acetone because the precipitate that I obtained with alcohol was so fine that my centrifuge would not settle it.

I first added an equal amount of acetone to 50 ml of my enzyme solution after chromatography and adjusted the pH to 3.5. I let this solution stand overnight and then centrifuged it. The liquid was poured off and any precipitate was saved. Then the pH was increased one unit and the preceding procedure repeated. I followed this process up to pH 10.5 and obtained two precipitates, one at pH 4 and the other at pH 9.5.

I read that proteins in a high concentration of an organic solvent will precipitate at their isoelectric point. Since I had also read that enzymes are proteins, I figured this would be a good way to precipitate my enzyme. I took these precipitates and redissolved them in 20 ml. of distilled water.

When I tested my original solution and the two precipitates, these were the results I obtained: 3 ml of the original enzyme solution acting on 3 ml of 0.1 molar sucrose at 30° C. for 72 hours hydrolyzed .7 mg. of sucrose. pH 4 precipitated under the same conditions hydrolyzed only 2.4 mg. of sucrose, while the pH 9.5 precipitate hydrolyzed *over* 9 mg. of sucrose, which is the limit of my test capacity. I decided to work on the pH 9.5 precipitate.

I was curious as to why I should get two active precipitates. I found the answer to this question in a book entitled *Introduction to the Chemistry of Enzymes*. It seems there are two enzymes which hydrolyze sucrose. One attacks the molecule through the fructoside linkage. In the near future I would like to purchase some methyl glucoside and see if my enzyme would attack it. Since this compound contains only the glucoside linkage, it would only be attacked by the enzyme which acts on the glucoside linkage. In this way I could tell which enzyme I am working with.

I am making up a fresh enzyme solution at present and I have a great many different experiments planned. An idea of my own which I plan to try involves making a series of buffer solutions to cover the isoelectric point of the enzyme and connect the containers by siphon tubes. Then when two electrodes are dipped into the solution the enzyme would migrate to the container which held a solution of the enzymes at the isoelectric point.

Like any true scientist, David is planning additional experiments.

Project and Club News

Needed—Projects for Uncle Sam

THERE are more than 300 problems, presenting challenges in almost every field of science technology, to which the Armed Forces is currently seeking solutions. Many of these problems make excellent science projects.

Here are just a few of the problems confronting the Armed Forces:

Do you have any ideas on how the Armed Forces can keep water from collecting in the barrels of rifles and machine guns—perhaps by destroying the surface tension of the water? Or how to make a paper-basis material for clothing that can be worn and thrown away?

In the field of rocketry there is an urgent need for a one-shot, lightweight structure made of something other than metal. Control systems, a major source of missile failure, must be improved, and so must guidance systems.

Military mechanical engineers are looking for ideas for such things as lightweight laundry equipment which uses little or no water; a device to boil a bucketful of water in five minutes; and noise suppressors for jet engines.

Problems facing military chemists include new solar cells, metals, and fabrics. A lightweight, polishable substitute for quartz is needed for telescope mirrors. There is a continuing requirement for new polymeric materials with better strength, heat resistance, low-temperature flexibility, and resistance to chemicals and radiation. In electronics, improved transistors and microwave oscillators are required.

If you have suggestions for the solution of these and some 300 other technical problems, ranging from outer-space puzzlers to needed products which may be invented on the kitchen stove, the National Inventors Council, U. S. Department of Commerce, would like to hear from you. The list of 300 problems may be obtained by writing to National Inventors Council, U. S. Department of Commerce, Washington 25, D. C.

How do you go about tackling one of the 300 problems suggested by the Armed Forces—or any science project? Here are some clues which may put you on the right track.

"Look Up" Project

You may discover that your science club has a very useful file of project papers, photographs, and working drawings done by club members, as well as a library of books, pamphlets, and scientific magazines and journals.

Such a collection of literature might include *Thousands of Science Projects* (Science Service, 1719 N Street NW., Washington 6, D. C., 25¢); special issues of *Chemistry* magazine containing Science Talent Search project papers (Science Service, 25¢); *Dental Projects for High School Students* (Science Service, 25¢); *Laboratory Experiments with Radioisotopes* (Supt. of Documents, Washington 25, D. C., 35¢); *If You Want to Do a Science Project* (National Science Teachers Association, 1201 16th Street, Washington 6, D. C., 50¢); *Student Projects* (National Science Teachers Assn., 50¢); *How to Do an Experiment*, Philip Goldstein (Harcourt, Brace & Co., $2.60).

Of course, back issues of *Science World* and *Tomorrow's Scientists* will be very helpful.

Your science club sponsor probably will be glad to let you look over the sections of the *Sponsor Handbook* that suggest research for student-scientists and list free and low-cost science material. He will also let you read the abstracts of Science Talent Search papers that are included in each edition of *How You Can Search for Science Talent*.

School and public libraries have many resources for the projecteer besides the most obvious ones of reference volumes and texts in your special field.

In the "vertical file" of pamphlets and leaflets you may find information or sources of information you haven't discovered elsewhere. In the *Readers' Guide to Periodical Literature*, the *Engineering Index*, the *International Index*, and other similar guides, you can search out articles that have been published on your subject.

Dividends of New Understanding

Ask the library staff, also, about current issues and bound volumes of professional journals that may not be indexed in guides available to you.

If there is a university in your area, you may be able to use its library resources, especially if you have a written request from your sponsor or teacher. You might investigate, also, the possibility of using the research library of a nearby industry, foundation or government agency.

Whatever time and resourcefulness you invest in looking up your project will yield dividends of new depth and breadth of understanding, and of exact and current facts in the field of your special project.

Space travel was theme of project by Mitchel Burriss, 17, Greenville (S. C.) H. S., at Regional Science Fair. Sealed "capsule" contained aquatic and terrestrial animals and plants, showed that animal and plant life maintain each other.

Space Prophet

(Continued from page 24)

nected with the atmosphere—the problem of re-entry. A rocket plunging earthward from the thin upper atmosphere smashed into the denser lower atmosphere with the force of a speeding car smashing into a brick wall. The rocket glowed from friction.

Von Braun discovered that many of his rockets were not surviving this battering. They were breaking in two about a mile above the target. By examining the wreckage, von Braun pinpointed the weak spot—a tiny air space between the fuel tanks and the rocket's outer "skin." He strengthened this area by stuffing it with glass wool.

From 13 Pounds to 50,000

Now the rocket was ready to be built. But the rocket would have to be steered somehow as it blasted off the ground. Von Braun decided to install an automatic pilot guided by a tiny electronic brain. The rocket would blast off vertically. Then the automatic pilot would tilt it to the proper angle.

By this time, World War II was raging in Europe. Von Braun's team set to work to build a war rocket—the V-2. (The "V" stood for "vengeance weapon.") The V-2 could carry a 2,200-pound warhead to a target 200 miles away. The 46-foot-long rocket's motor delivered a thrust of 50,000 pounds (3,600 mph).

Fortunately for England—the prime target of the V-2—the German High Command was short of funds. The first successful V-2 was tested in October 1942. Not until September 1944 was the first V-2 fired against England. Six months later, a battered Germany surrendered to the Allies.

For Tomorrow—Project Saturn

On May 2, 1945—two days before the fall of Nazi Germany—Wernher von Braun surrendered to an American GI. Today Dr. von Braun lives in Huntsville, Alabama, with his wife and two daughters. He is now a naturalized American citizen. About 120 other German rocketeers also came to the U.S. with Dr. von Braun. They form the core of his team at Redstone Arsenal in Huntsville. In 1958 the team orbited the free world's first Earth satellite.

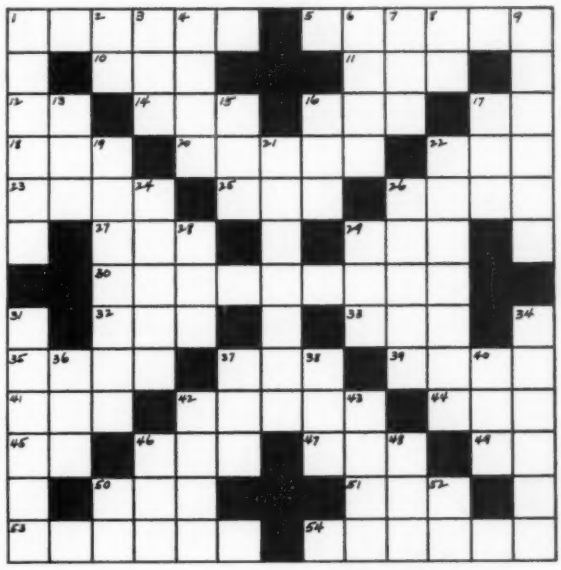
Next year Dr. von Braun expects to be transferred to the civilian-controlled National Aeronautics and Space Administration. Meanwhile, he is developing Project Saturn, a 1,500,000-pound thrust rocket engine (*see the Sept. 23 issue*), a far cry from the 13-pound thrust of the Berlin days.

Who's Who in Science

By Mary Ruth Burress, Dawson Springs (Kentucky) High School

★ Starred words refer to famous scientists

Students are invited to submit original crossword puzzles for publication in *Science World*. Each puzzle should be built around one topic in science, such as astronomy, botany, geology, space, electronics, famous scientists, etc. Maximum about 50 words, of which at least 10 must be related to the theme. For each puzzle published we will pay $10. Entries must include symmetrical puzzle design, definitions, answers on separate sheets, design with answers filled in, and statement by student that the puzzle is original and his own work. Keep a copy as puzzles cannot be returned. Give name, address, school, and grade. Address Puzzle Editor, Science World, 33 West 42nd Street, New York 36, New York. Answers to this puzzle are on page 30.



ACROSS

* 1. American scientist, _____ Henry.
* 5. 17th-century French scientist noted for studies on barometric pressure.
10. National Recovery Administration (*abbr.*).
11. Electrified particle formed when a neutral atom loses or gains one or more electrons.
12. "Yes, We have _____ Bananas."
14. Playing card with single spot.
16. Find the sum of.
17. Foot-second (*abbr.*).
18. Short sleep.
20. Honorary society, Phi Beta _____.
22. Acquire, procure.
23. Poetic name for Ireland.
25. Sailor or seaman.
*26. Mendel demonstrated and Johannsen named this unit of heredity.
27. Book club sponsored by *Scholastic Magazines* (*initials*).
29. Homo sapiens.
*30. 4th-century B. C. Greek scientist and philosopher.
32. Domesticated animal.
33. Series (*abbr.*).
35. Periods or stages of time.
37. The annoying 60 or 120 cycle tones heard in the output of communication equipment.
39. Slender, pointed piece of metal.
41. Rodent larger than a mouse.
42. Pale yellow liquid in the blood.
44. Tennis ball returned in high curve.
45. Kitchen Police (*abbr.*).
46. Two thousand pounds.
47. Disfigure, injure.
49. Neon (*chemical symbol*).
50. A fluid colloidal solution.
51. Jewish holiday, _____ Kippur.
*53. He discovered the laws of gravitation in 1665.
*54. 17th-century scientist who gave the cell its name, _____ Hooke.

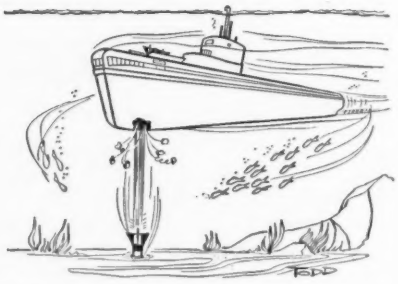
DOWN

* 1. English physician, discoverer of smallpox vaccine.
2. Tin (*chemical symbol*).
3. Singular form of 35 across.
4. Group of wolves.
6. Opera by Verdi.
7. Grass-covered earth, turf.
8. American Admiral during World War II, ___hester ___imitz.
* 9. English discoverer of antisepsis.
13. Used for rowing a boat.
15. Consume, devour.
16. Fourth month (*abbr.*).
17. Low marsh land.
19. Light, repeated sound; pattering.
*21. French chemist, discovered cure, prevention of hydrophobia.
22. President Eisenhower's former title.
24. The nostrils.
*26. 2nd-century A. D. Greek physician, famous for studies on anatomy.
28. Steel part of bridle inserted in a horse's mouth.
29. The Blue Ridge _____ (*abbr.*).
*31. English chemist, produced first artificial dye in 1856.
*34. He developed the equation of $E = MC^2$ (*first name*).
36. Strike sharply.
37. Female fowl.
38. Silent.
40. A gas molecule that loses an electron becomes a positive _____.
42. Performance by one person.
*43. Physician brothers, founders of the famous foundation for medical research in Minnesota.
46. Small child.
48. Steal.
50. Southwest (*abbr.*).
52. Objective case of *I*.

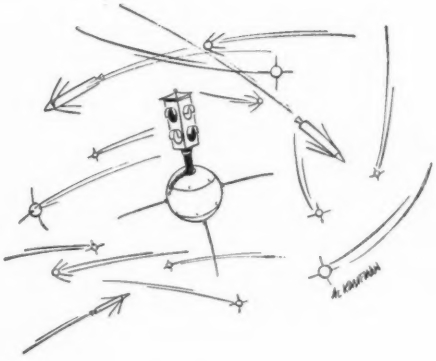
sci-fun

Stamaty

"Automation is creeping into everything."



"If I've told you once I've told you fifty times, *nose cone* up, fins on the bottom."



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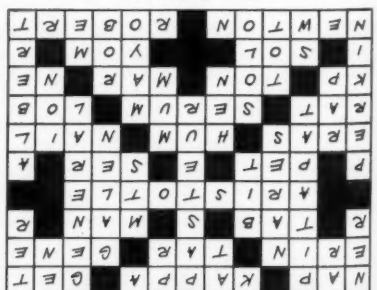
Crossword Puzzle Answer

(See page 29)



Science Bookshelf

ADVENTURES IN THE WORLD OF SCIENCE, by Charles G. Abbot (Public Affairs Press, Washington, D. C., 1959, 150 pp., $3.50.)

A scientist-scholar, who has been closely associated with many significant scientific developments of the twentieth century, describes in this autobiography his work with the Smithsonian Institution and his friendship with men and women of science.

Dr. Abbot was associated with the Smithsonian Institution, the important center for scientific knowledge in the United States for almost 50 years. He served as secretary from 1928 to 1944.

The author has had a continuing interest in scientists and their struggles. When others looked askance at Dr. Robert H. Goddard, the American pioneer in astronautics, Dr. Abbot offered him warm encouragement and generous assistance that enabled him to go on with his work.

Dr. Abbot, recognized as an astrophysicist in his own right, devotes one section of the book to his research in solar power and weather prediction. The author, despite his years, maintains a lively interest in creative science. Last month he was granted a patent for a solar engine.

LIVING INSECTS OF THE WORLD, by Alexander B. Klots and Elsie B. Klots (Doubleday & Company, Inc., Garden City, N. Y., 1959, 304 pp., $9.95.)

This fourth volume in the *World of Nature* series has a spectacular collection of 277 photographs, including 153 in full color.

The Klotses, a husband and wife writing team, have drawn from a lifetime of experience in the Canadian Arctic, the Americas, Europe, and tropical Africa, studying the life-cycles of insects and their behavior. There are fascinating stories of insects using jet propulsion, gyroscopic stabilizers and snorkels, African driver ants that can rout a village, crickets whose chirps tell you the temperature.

The authors discuss the importance of insects to man, how they benefit or damage agriculture, destroy food and carry disease, and the effort made to control them. There is considerable material on the evolution and organization of insect societies.

Dr. Alexander B. Klots is Associate Professor of Biology at the City College of New York and Research Associate of the American Museum of Natural History. Dr. Elsie B. Klots has taught at Cornell University, Elmira College, and other schools. —LAVINIA DOBLER

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ON "CONQUEST"—NOV. 29, THE LADDER OF LIFE!

"CONQUEST" marks the 100th anniversary of the publication of Charles Darwin's theory of evolution with a documented film that proves it before your very eyes. Dr. H. B. D. Kettlewell shows certain moths evolving strictly according to Darwin's law.

ON "CONQUEST"—DEC. 6, MYSTERY OF THE SUN

How do the great flaming explosions on the face of the sun cause radio blackouts on earth? "CONQUEST" monitors the sun with optical telescopes, follows rockets into the path of the flares to learn the true nature of these solar upheavals.

Presented in cooperation with the National Academy of Sciences, and the American Association for the Advancement of Science. Check your local television listing for time and station.

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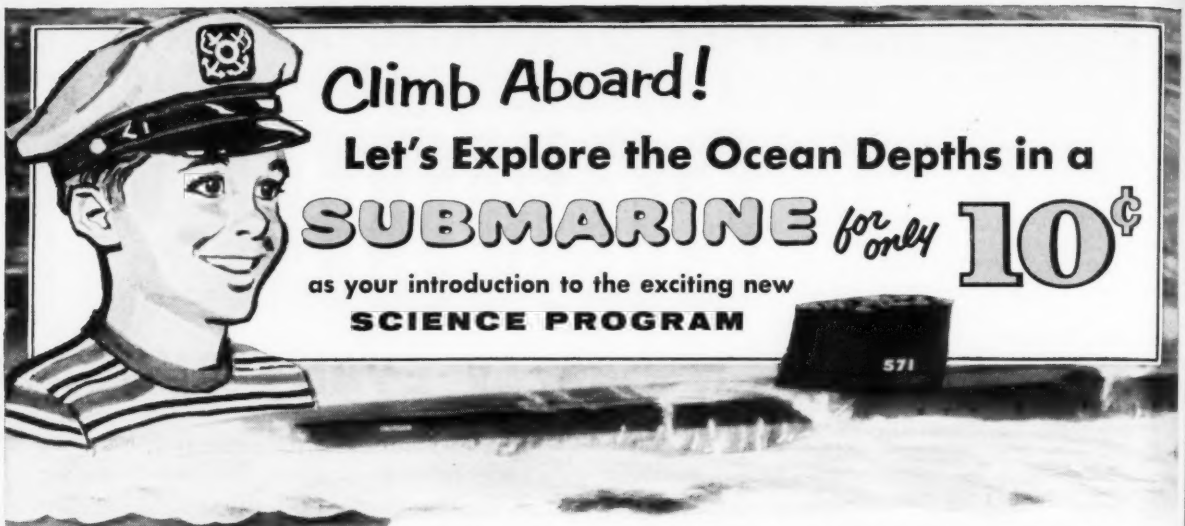

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It shattered the Japanese merchant marine in World War II, is still backbone of U.S. Navy's submarine forces.
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(Depth Secret)
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Look and Listen

Program Notes on Selected Radio-TV Features

EDITED BY PATRICK AND MARY HAZARD

All times shown are current in Eastern Zone. Programs subject to change. Check local stations before assigning programs to students.

DRAMA

Wed., Nov. 18, 10:00 p.m. (CBS-TV) **United States Steel Hour**: "The Last Autumn," adapted for television by Arthur Heinemann from the novel by Herbert Gutterson, starring Pat Hingle (of "J.B." critical acclaim) and Hollywood actress Alexis Smith. Directed by Michael Dreyfuss. The father of a boy killed in a field trip accident blames the negligence of an elderly teacher who dozed off while supervising the expedition. Investigation of the accident leads the father to reconsider both his angry reaction and his relationship with his son STUDY QUESTIONS: 1. Describe the character of Roger Conway, Justin Kendrick (the headmaster), Alan Richards (the young teacher), and Hugh Follensbee (the old teacher). Which man would have the best relationship with the boys in the school? Why? 2. What does Mr. Kendrick mean when he says that there is "a community of guilt" for the accident? 3. Why are we quick to accuse, like Mr. Conway, when accidents occur?

Thurs., Nov. 19, 9:30 p.m. (CBS-TV) **Buick Electra Playhouse**: Ernest Hemingway's short story, "The Killers," adapted for television by A. E. Hotchner, starring Dane Clark, Ray Walston, Diane Baker, Glenda Farrell. Dean Stockwell, Ingemar Johansson, and Frank McHugh. Directed by Tom Donovan.

Fri., Nov. 20, 10:00 p.m. (CBS-TV) **The Twilight Zone**. "Time Enough At Last," starring Burgess Meredith. Adapted by Rod Serling from a story by Lynn Venable about the last man left on earth after the bomb falls. Nov. 27: "Perchance to Dream" by Charles Beaumont, the story of a man who consults a psychiatrist when he finds that every sleeping moment is filled with dreams of his own death.

Sun., Nov. 22, 8:00 p.m. (NBC-TV) **Our American Heritage**: "The Practical Dreamer" by Paul Crabtree, a new insight into Eli Whitney as early prophet of the assembly line, starring Burgess Meredith. (See Teleguide, page 7-T.)

9:00 p.m. (CBS-TV) **General Electric Theatre**: Mayo Simon's "The Last Dance," starring Carol Lynley, Clint Kimbrough, Mary Astor, and Malcolm Atterbury, and directed by David Greene. A play for mature senior high students about the problems faced by two immature adolescents when their parents oppose their elopement. The growing problem of teen-age marriage is handled with taste and realism, an opportunity for the skillful teacher to discuss the problem with mature students. STUDY QUESTIONS: 1. How do we know that Gene and Phyllis have unrealistic ideas about the responsibilities involved in marriage? 2. What do these things show us about the young people's attitude toward marriage: the scorched shirt, the dinner with Gene's parents, Phyllis' new formal dress? 3. What unforeseen sacrifices must Gene and Phyllis make for their marriage? Why does Mayo Simon call his play "The Last Dance"? 4. Do Gene's parents handle the situation wisely? Do you think that the marriage can work out? Why or why not? Would the marriage have had a better chance if the couple had waited until graduation before marrying?

Thurs., Nov. 26, 9:30 p.m. (CBS-TV) **Playhouse 90**: "The Gray Nurse Said Nothing," an original mystery story by Sumner Locke Elliott, starring Angela Lansbury and Ann Todd.

Carol Lynley, Clint Kimbrough star in "The Last Dance," on *General Electric Theatre*, Nov. 22, 9 p.m. (CBS-TV).

Fri., Nov. 27, 8:30 p.m. (NBC-TV) **Special Tonight**: "Miracle on 34th Street," starring Ed Wynn as Kris Kringle, the man who believes that he is Santa Claus.

Sun., Nov. 29, 9:30 p.m. (CBS-TV) **Alfred Hitchcock Presents**: "Special Delivery," by science fiction writer Ray Bradbury. A young boy experiments with some strange mushrooms he receives through the mail.

Fri., Dec. 4, 7:30 p.m. (CBS-TV) **Du Pont Show of the Month**: "Oliver Twist."

MUSIC AND ARTS

Fri., Nov. 20, 8:30 p.m. (NBC-TV) **Bell Telephone Hour**: Gershwin program.

Sat., Nov. 21, 8:30 p.m. (CBS) **New York Philharmonic**: Under direction of Thomas Schippers, with Tossy Spivakovsky, violinist. Haydn's Symphony No. 102 in B flat; Prokofieff's Violin Concerto No 2 in G minor, Opus 63; selections from Wagner. Nov. 28: Under direction of Leonard Bernstein, with Zino Franciscati, violinist. Bach, Bartok, Beethoven

8:30 p.m. (NBC-TV) **The Pontiac Star Parade**: "The Gene Kelly Show" with Donald O'Connor and Carol Lawrence.

Sun., Nov 22, 10:05 p.m. (CBS, New York area; check your local station for time and schedule). **Invitation to Learning**: Knut Hamsun (Norwegian) "The Growth of the Soil." Nov. 29: Miguel de Unamuno's (Spanish) "The Tragic Sense of Life."

12:00 noon (ABC-TV) **Johns Hopkins File 7**: "Tonight Only: 'The Drunkard'." Lynn Poole tours a showboat.

Wed., Nov. 25, 10:00 p.m. (ABC-TV) **The Golden Circle**: A salute to a quarter century of songs, with Steve Lawrence, Eydie Gorme, Andrews Sisters, Frankie Avalon, Nat "King" Cole, Mills Brothers, Rudy Vallee.

Sat., Nov. 28, 2:00 p.m. (CBS) **The Metropolitan Opera**: Verdi's "Aida." The Met begins its 20th consecutive season of broadcasts with Milton Cross, commentator.

Sun., Nov. 29, 8:00 p.m. (NBC-TV) **Sunday Showcase**: Grammy Awards telecast with Meredith Willson, host, and many of the 34 recording artists scheduled for National Academy of Recording Arts and Sciences awards.

Tues., Dec. 1, 9:30 p.m. (NBC-TV) **Ford Startime**: "An Evening with Miss Ethel Merman," with Tab Hunter, Fess Parker, and Tom Poston.

Wed., Dec. 2, 10:00 p.m. (CBS-TV) **Marriage—Handle With Care**: A Sid Caesar special, spoofing ideas about love, courtship, and marriage. With Audrey Meadows, Marge and Gower Champion, and Connie Francis.

PUBLIC AFFAIRS

Sat., Nov. 21, 4:00 p.m. (WNYC, New York; check local NAEB station for time and schedule) **Everybody's Mountain**: "Geometry in the First Grade at Stanford Elementary School in Palo Alto." Nov. 28: "The Community School Idea in Flint, Michigan." New series on educational experiments.

Sun., Nov. 22, 12:30 p.m. (CBS-TV; also CBS radio, 8:30 p.m.) **Face the Nation**: Governor Nelson A. Rockefeller.

6:30 p.m. (CBS-TV) **The Twentieth Century**: "Goering." Nov. 29 and Dec. 6: "Poland on a Tightrope" in two parts. Part I: "The Reluctant Satellite." Part II: "Back in Orbit."

FOR YOUNGER VIEWERS

Fri., Nov. 20, 7:30 p.m. (ABC-TV) **Walt Disney Presents**: "Mustang Man, Mustang Maid." Elfego Baca defends a band of persecuted nomads.

Sat., Nov. 21, 1:00 p.m. (NBC-TV; carried eight days delayed, N.Y. area) **Watch Mr. Wizard**: "Proof of Molecules." Betty Sue, with Mr Wizard's help, proves that molecules exist by using three historic experiments.

8:30 p.m. (ABC-TV) **Leave it to Beaver**: "Beaver's Tree." Inspired by a poem read in school, Beaver adopts a tree for his personal attention.

Sun., Nov. 29, 5:00 p.m. (ABC-TV) **Art Carney Meets Peter and the Wolf**: with the Baird marionettes.

7:30 p.m. (ABC-TV) **Shirley Temple's Storybook**: "Rapunzel."

SCIENCE AND EXPLORATION

Sat., Nov. 21, 8:00 p.m. (ABC-TV) **John Gunther's High Road**: "Men Will Find a Way," the story of how people in two obscure villages cooperate to save their towns from economic extinction.

Mon., Nov. 23, 6:30 a.m. (NBC-TV) **Continental Classroom**: Modern Chemistry with Dr. John F. Baxter. Today's lesson: Solubility, with guest lecturer, Dr. Joe H. Hildebrand, professor of chemistry, U. of Calif., Berkeley. Nov. 24: Hydrogen Chloride. Nov. 25: Bronsted-Lowry Acid-Base Theory. Nov. 26, 27: Thanksgiving recess. Nov. 30: Acid-Base Reactions; Indicators. Dec. 1: Relative Strengths of Reactants. Dec. 2: Tabulating Acids and Bases. Dec. 3: Applications of the Table of Predicting Reactions. Dec. 4: Other Acid-Base Theories.

Sun., Nov 29, 12:00 noon (ABC-TV) **Johns Hopkins File 7**: "Sanitary Engineering." The problem of industrial waste.

5:00 p.m. (CBS-TV) **Conquest**: "The Bottom of the Sea." (See Teleguide, page 5-T.)

National Radio and TV programs by representatives of religious faiths are listed once each semester.

EXPERIMENT:

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CENTRIFUGE TUBE (15 ml)	1.28	1.28	0.69
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